MAY 1960

modern castings



Preview Issue

AFS CASTINGS CONGRESS AND EXPOSITION

Philadelphia, May 9-13

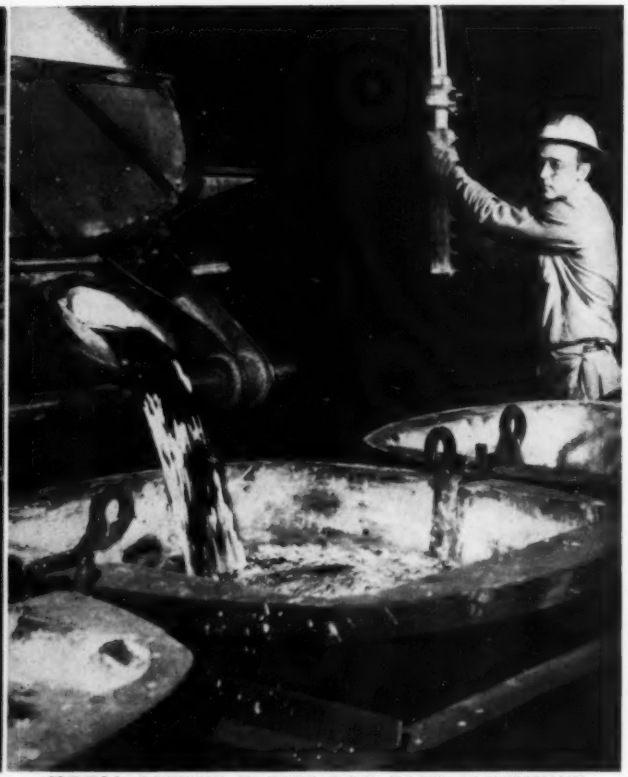
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YOU, MR. FOUNDRYMAN, A V.I.P. AT



DEPENDABILITY OF SUPPLY. From this huge new plant in Ohio comes a steady supply of primary casting alloys for the foundry industry—sold either directly or through Olin Aluminum Casting Alloy distributors throughout the nation.



METAL ALWAYS FLOWS FOR OLIN ALUMINUM CUSTOMERS. We allot a permanent percentage of this metal to casting alloys—assuring our customers and distributors of continuous performance despite any fluctuations of supply and demand.

The red carpet is always out for foundrymen at Olin Aluminum, as shown by our membership in the American Foundrymen's Society. Our Casting Alloys section is headed up by men with a solid background in the foundry industry. We consider any problem of yours to be a problem of ours.

We know your needs, and we ride herd on every processing step from mine to potline to make sure that each Olin Aluminum ingot is up to the mark on quality, purity and analysis. We maintain—and follow—one of the most detailed Customer Requirement Records in the industry. And we don't sell castings ourselves—

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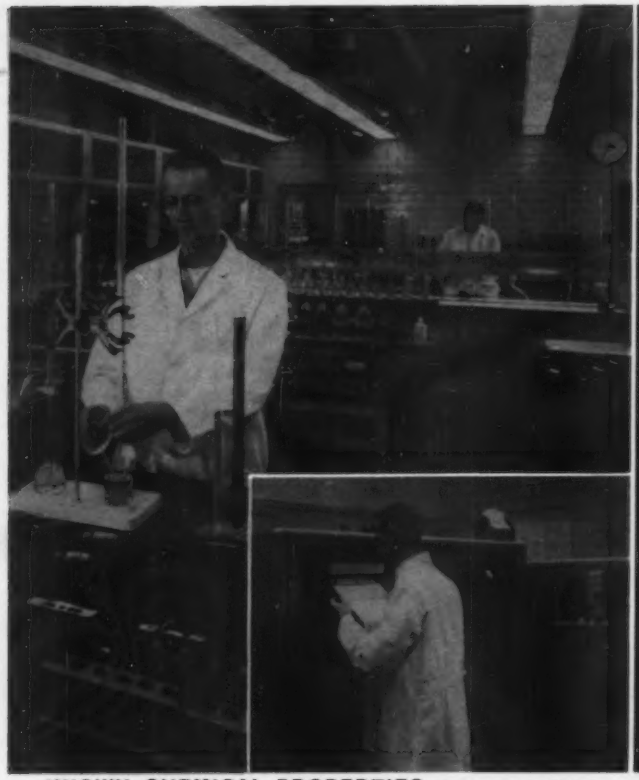
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ARE ALWAYS OLIN ALUMINUM



KNOWN CHEMICAL PROPERTIES. Every melt of Olin Aluminum undergoes exacting metallurgical and production controls. Skilled metallurgists use the latest and most efficient analytical and physical testing equipment.



MORE EFFICIENT FORMS. Olin Aluminum standard casting alloys come in 10, 25 and 50-lb. sizes. The 10 and 25 pounders feature smaller size to facilitate crucible charging, speed handling and melting. Deep notches and 4-section design are for easier breaking.

our policy is to help you to produce good castings. Our Technical Assistance is always available to you. This is only one of the many services we offer. Make Olin Aluminum your source of superior casting alloys — and of metallurgical know-how. Call your local Olin Aluminum office or distributor listed below.

SEE US AT THE PHILADELPHIA CASTINGS CONGRESS BOOTH 1022-24 MAY 9-13

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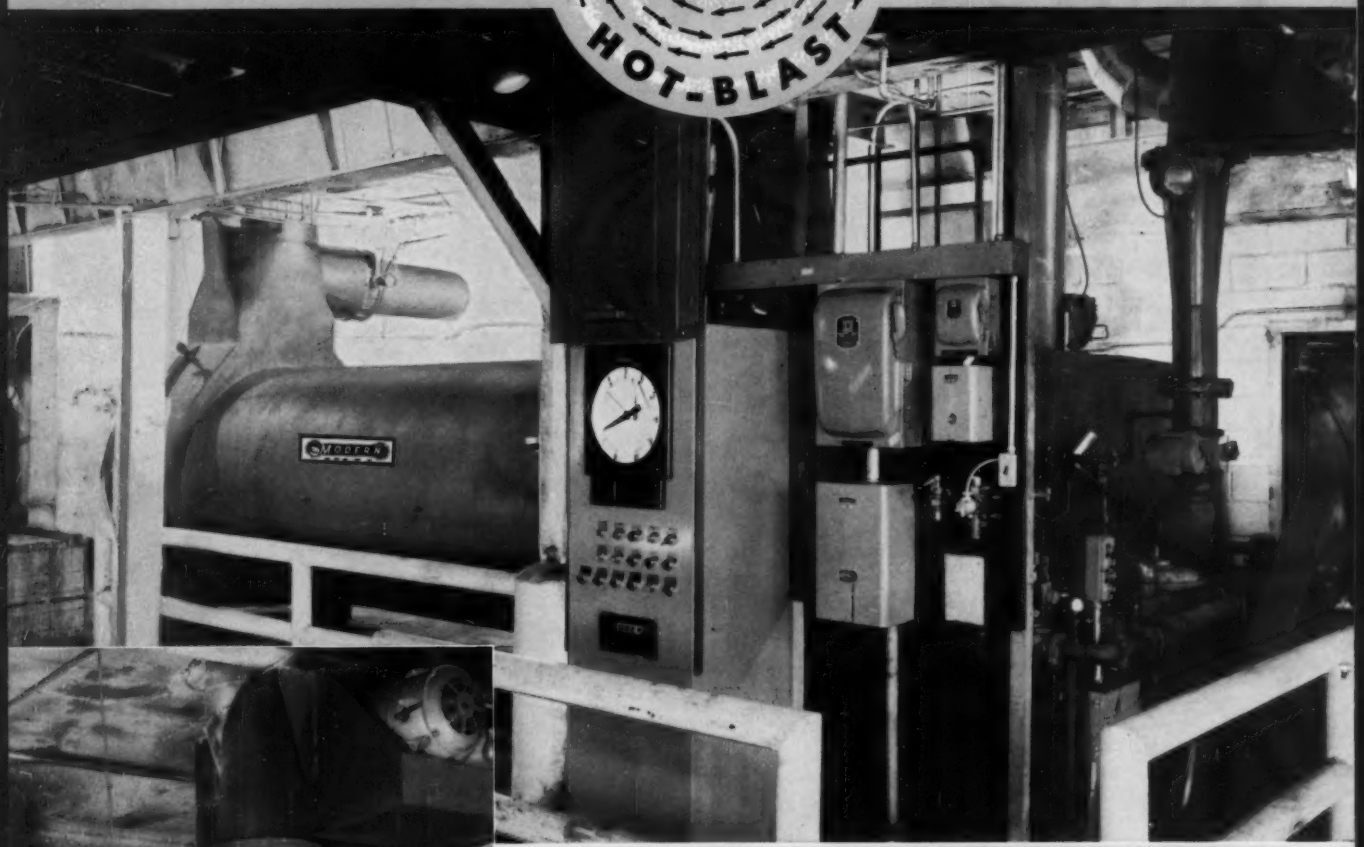
OLIN MATHIESON • METALS DIVISION
400 PARK AVENUE, NEW YORK 22, N. Y.

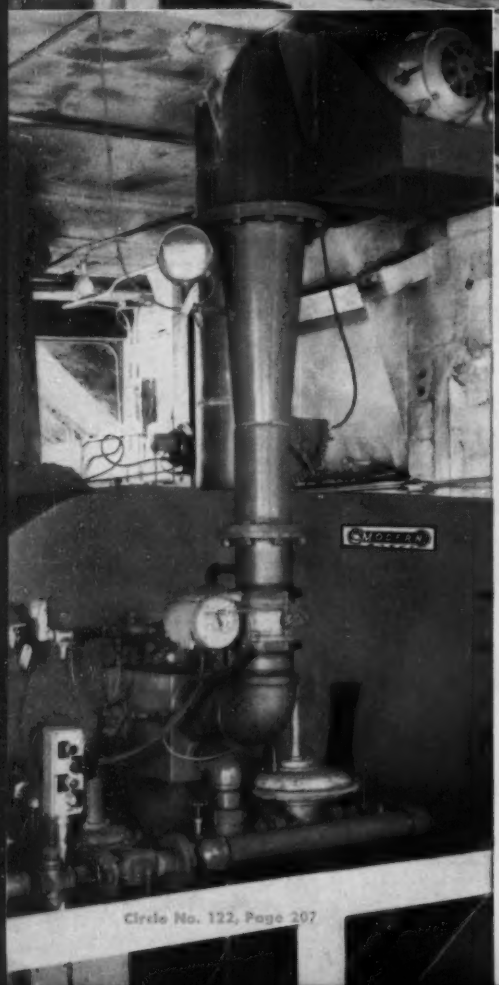
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MODERN

RECIRCULATORY Eff. to 85% HOT-BLAST

COST CUTTING!





750° F., MODERN, hot-blast heater is supplying 7500 CFM to MODERN, externally, water-cooled cupola at Neenah Foundry Co., Neenah, Wis.

NOTE: Names of other heater installations, in foundries, supplied on request.

ASK ALL ABOUT IT...Booth 1409

Recirculating the products of combustion boosts efficiencies as high as 85% in MODERN, indirect-externally-fired, hot-blast heaters. The counter-flow and cross-flow principle of gas-to-air heat transfer provides a scrubbing action which results in a higher, heat-transfer coefficient. The smooth inner and outer surfaces of the tubes assure minimum pressure drop and maximum tube cleanliness. Pilot, ignition and safety equipment meets all state safety codes.

MAJOR USER BENEFITS INCLUDE:

- *Lowered coke ratios . . .*
- *Reduced oxidation . . .*
- *Decreased refractory cost . . .*
- *Uniform metal temperatures . . .*
- *Hotter iron is tapped . . .*
- *Bridging is eliminated . . .*
- *Fewer castings scrapped . . .*
- *Lower sulfur pick-up . . .*
- *Increased melting efficiency . . .*
- *Less costly charge substitute . . .*
- *Chemistry is more uniform. . .*
- *Melting rate increased . . .*

Since every hot-blast requirement does present individual problems we welcome every opportunity to discuss the over-all need in its early planning stages . . .

MODERN EQUIPMENT COMPANY
Dept. MC-5
Port Washington, Wisconsin

REPRESENTATIVES IN ALL PRINCIPAL CITIES

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modern castings

technical magazine of the metalcasting industry

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A series of eight presentations of advanced metalcasting technology in the following areas:

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JUNE ISSUE

Special Post-Congress Number

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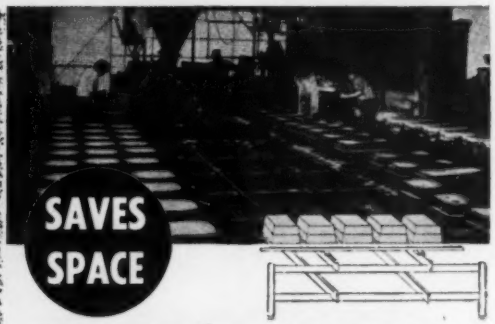
MODERNIZE . . . and COMPETE!

NOMAD EQUIPMENT helps you produce more molds per day! Each man-hour is more productive because molds are no longer carried away by the molder. Instead, molds "roll away" smoothly, without vibration on track conveyors.

THERE'S AN *ADDED* VALUE BUILT INTO NOMAD EQUIPMENT . . . It's the great number of track and equipment combinations which are possible. There's a conveyor system to fit your needs!

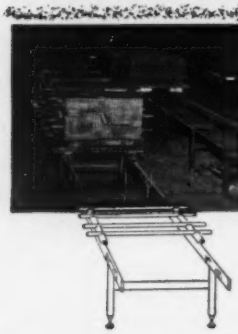


NOMAD RECESSED CONVEYORS give great flexibility to jobbing operations or to foundries which pour once a day. It is especially useful for short or long runs and cope and drag or squeezer jobs. Also, the whole area can be worked freely by a front-end loader.



SAVES SPACE

NOMAD DOUBLE LEVEL TRACK provides 2 conveyors in the place of 1 and EXPANSION without requiring new building facilities! The top track is used for storage and pouring. Empty pallets return and are stored on the bottom track until needed. Productivity is increased greatly by installing a pallet raiser and mold dump to each line.



THERE'S LOW COST MODERNIZATION with Nomad Single Track Conveyors. It requires a minimum amount of space and accommodates both bottom boards or pallets. COMPLETE MOBILITY is possible by adding switches, transfer cars, turntables and curves.

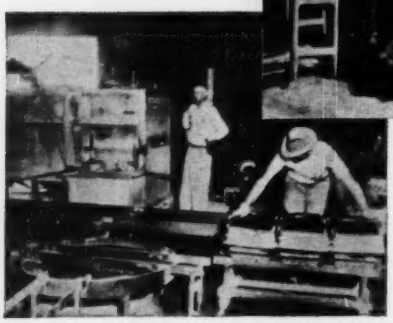
ONE MAN HANDLES THE DUMPING FOR THE *ENTIRE* FOUNDRY!



Nomad's mold dumps are simply designed and sturdily built for fast dumping and effortless operation. The stationary, gravity type (above) serves a single mold line. Movable dumps ride on transfer track to serve SEVERAL lines.

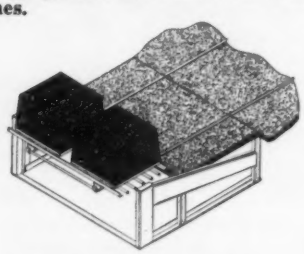
AUXILIARY EQUIPMENT "CUTS CORNERS"





You'll conserve valuable floor space, achieve highly flexible layouts by using curves, switches, turntables and transfer cars.

SAVES MOLDERS' TIME AND ENERGY!



Pallet raisers are used at the molder's end of Double Level Track to raise pallets into position to receive molds.

See our *NEW* SHAKEOUT-PUNCHOUT UNIT for handling tight flasks — BOOTH 1137-39



MUSCLES

A.F.S. Convention
Philadelphia, Pa.
May 9 to 13

NOMAD EQUIPMENT CORPORATION
3110 W. FOND DU LAC AVE., MILWAUKEE 10, WIS.
Designers and Manufacturers of
Complete Conveyor Systems

NOMAD EQUIPMENT

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modern castings

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GENERAL MANAGER
WM. W. MALONEY

Let's look at...

YOUR MAGAZINE TODAY


Wm. W. Maloney

WILLIAM W. MALONEY, known to many of you as "Mr. Association," quite properly points out that 1960's most important metalcastings event takes place this month. It's the mammoth 64th AFS Castings Congress and Exposition. Some 15,000 foundrymen are expected to attend (See page 47).

There's also another important, regular and exclusive AFS service for you: MODERN CASTINGS magazine. Each month you get this quality product—"the most" in editorial pages and content. Only in MODERN CASTINGS can you find:

First, Castings Congress papers, the editorial "Oscars" of the industry. Covered are the important phases of technology, practices and management today. Prepared under the expert direction of internationally-known and respected S. C. Massari, they are an "exclusive." They appear in MODERN CASTINGS *only* after a national committee of outstanding authorities has approved them. (See page 94).

Second, a specially designed feature section. This is personally sparked by our Editor—a man who came to us after a successful and broad career in the metalcastings industry. Incidentally, in this issue you will find a significant "exclusive" on page 82.

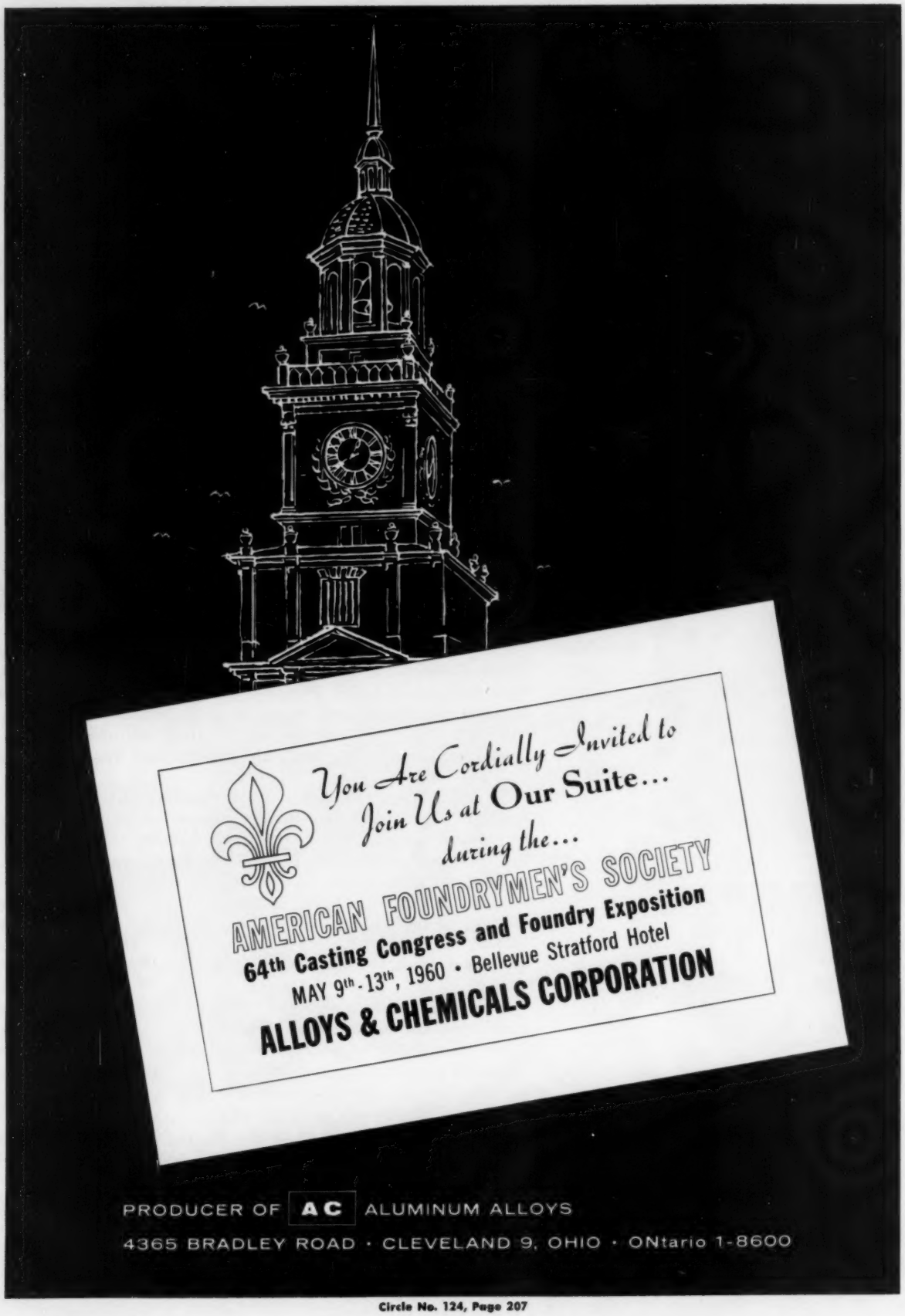
Third, the counsel of recognized specialists. There's H. J. Weber on safety and hygiene. H. F. Dietrich provides sage know-how on industry problems—leadership advice. On page 34 is a practical column on educational needs by R. E. Betterley. On the back page you'll find trends and tips by Editor Jack Schaum, an experienced analyst.

Fourth, the most complete and significant news coverage—events, people and information. The lifeblood of *every* industry!

In other words, MODERN CASTINGS gives you each month an important parade of experts, events and exclusive information. You will also find an unusual amount of information on new products, processes and data—an editorial bonus.

Exclusive benefits will be added to all these in forthcoming issues. We hope that you, as a valued reader, will participate even more as these new services come to you.

Harold E Green



Circle No. 124, Page 207

PAYLOADER® is more productive



more digging and breakout power

Unusual digging power is only one feature of the H-25 that makes it the most productive tractor-shovel in its size range. Following are some of the other features and basic reasons why the H-25 "PAYLOADER" is outstanding in its class:

Full Power-shift Transmission with two speed ranges forward and two speed ranges reverse, plus matched, single-stage, two-phase torque converter.

Power-steering and the smallest turning radius (only 6 ft.) in its class.

Power-transfer Differential giving more reliable traction on slippery conditions by reducing drive-wheel spin-out.

Protected for Long Life by the most complete system of built-in insurance: oil filters; triple air cleaners; sealed hydraulic service brakes and enclosed parking brake; closed pressure-controlled hydraulic systems; oil and grease seals; other protective devices.

Whether your bulk-handling needs require the Model H-25 with 2,500 lbs. operating capacity, or larger tractor-shovels — up to 12,000 lbs. operating capacity — you'll find a "PAYLOADER" is the standard of *any* comparison. Your Hough Distributor is ready to prove it, and has the finest service and parts facilities in the business, backed by Hough factory service personnel.

Two extra-large hydraulic cylinders develop the tremendous bucket breakout, tip-back force of 4,500 lbs. at the cutting edge — more than is available on any other machine in its size range.

HOUGH®

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LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave., Libertyville, Ill.

☐ Send H-25 "PAYLOADER" data.

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Title _____

Company _____

Street _____

City _____ State _____

5-A-1

Circle No. 125, Page 207

METALGRAMS

. . . news about "Electromet" ferroalloys and metals

UNION CARBIDE METALS

MAY, 1960

EYES ON PHILADELPHIA -- The week of May 9-13 will see thousands of foundrymen descend on Philadelphia to attend the 64th AFS Castings Congress and Exposition. They'll attend technical sessions covering the latest production techniques and metallurgical developments and visit exhibits featuring new equipment and materials. For the latest uses of ferroalloys to produce better castings, foundrymen will want to visit Union Carbide Metals' extensive exhibit covering 41 foundry alloys. Featured are alloys that give better properties to cast iron, allow more efficient production of ductile iron, cut costs of steel, and give greater purity to aluminum.

* * *

ON-THE-SPOT INFORMATION -- Questions on the selection and use of ferroalloys will be welcomed at the Union Carbide Metals' exhibit at the Foundry Show. Experienced metallurgists and engineers will be on hand to provide on-the-spot assistance. You are cordially invited to visit the exhibit and talk to UCM personnel. See us at booth No. 1214.

* * *

ADDS HEAT -- Some iron foundries making chromium additions to the ladle have found that as much as one per cent chromium will dissolve readily when added as "Chromtemp" exothermic ferrochrome. The exothermic reaction of the alloy rapidly brings the addition to white heat, resulting in fast solution and consistently high chromium recovery. Temperature loss resulting from the alloy addition is negligible. Ask your Union Carbide Metals representative for further information and specification sheet, F-20,124.

* * *

ALLOYS IN MALLEABLE IRON -- Malleable producers are showing greater interest in the improved production possible with tiny amounts of alloying elements. For example, about 0.002 per cent boron, conveniently added in the cupola as boron-bearing ferrosilicon or to the ladle as ferroboron, cuts the annealing time of castings by as much as one-third. Boron also counteracts residual elements like chromium which retard formation of the malleable structure. For further information on alloy additions, plus new data on high-temperature properties of malleable castings, write for the article, "Malleable Iron Lifts Its Temperature Barrier," in the Winter 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

GASES ARE FLUSHED OUT -- A new alloy -- magnesium-calcium-silicon -- has been used successfully to flush out gases in high-alloy heats melted in the induction furnace. The alloy is added to the ladle and produces a vigorous flushing action. One producer reduced his rejection rate caused by gas imperfections from 30 to 5 per cent on a 35 per cent nickel, 15 per cent chromium casting. The case history can be found in the article, "Rejections Cut With New Alloy," in the Winter 1960 issue of UNION CARBIDE METALS REVIEW or contact your UCM representative for further details.

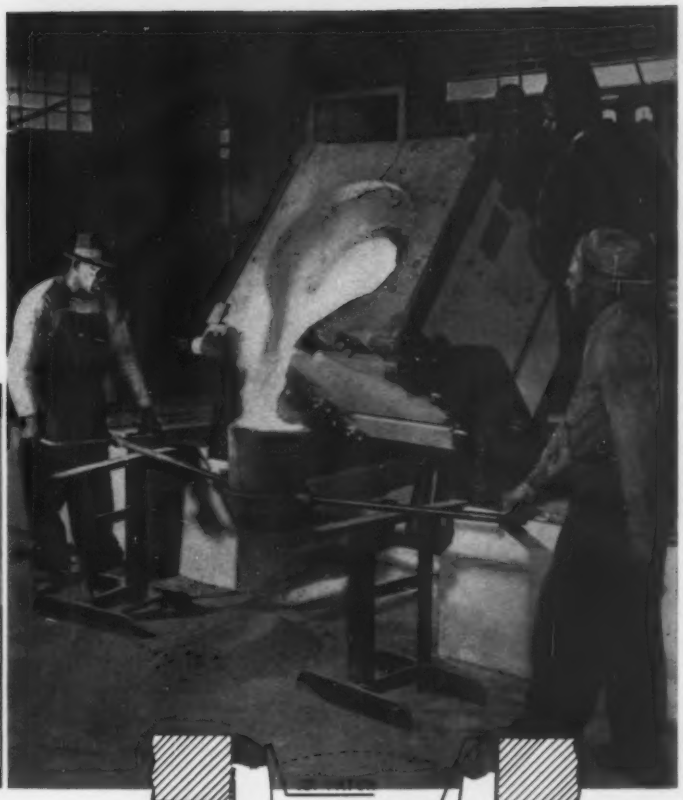
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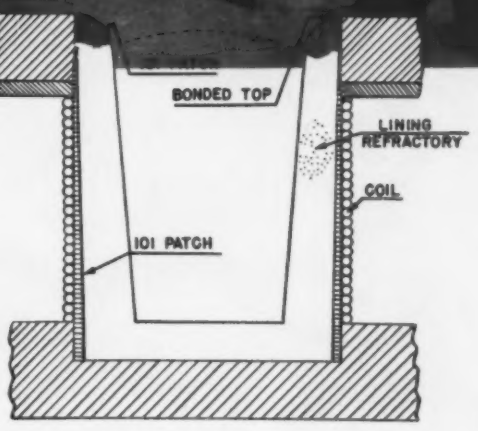
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USE

TASIL NO. 101 PATCH



for high frequency induction furnaces



TASIL (Taylor Sillimanite) No. 101 Patch is widely used by operators of high frequency induction furnaces for coating of the inner surface of the water-cooled, primary coil. When air dried, this coating will:

1. **Protect the coil when the crucible is being rammed in place.**
2. **Protect the coil from damage in the event of a leakage of metal through the lining proper.**

Properties which qualify TASIL No. 101 Patch for this service are: *high di-electric strength . . . smooth working properties . . . softening point above 3200° F. . . . negligible shrinkage or expansion . . . can be used with either an acid or basic lining.*

There is a complete line of TASIL (mullite), TAYCOR (corundum-base) and TAYLOR ZIRCON Ramming Mixes and Cements for every metallurgical need. Write for recommendations to cover your melting requirements.

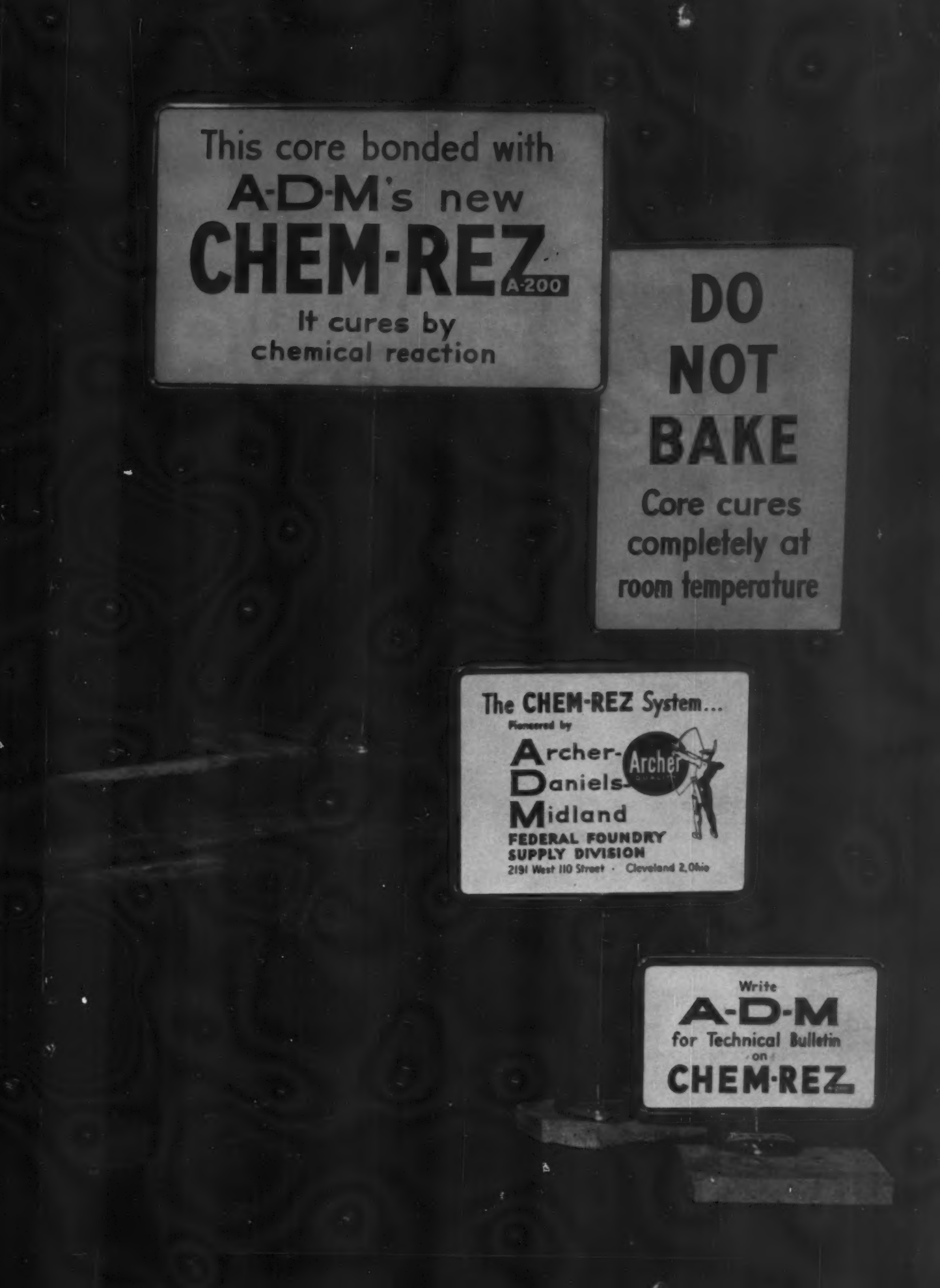
The CHAS. TAYLOR SONS Co.
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Circle No. 128, Page 207


EMERGENCY ORDER
60 minutes from muller to mold
HANDLE CORE ONLY ONCE
Bypass ovens. Route directly to molding floor
WATCH FOR COLOR CHANGE
From brown to green to black as it cures
See
CHEM-REZ A-200
at the Foundry Show Philadelphia


This core bonded with
A-D-M's new
CHEM-REZ
A-200
It cures by
chemical reaction
DO
NOT
BAKE
Core cures
completely at
room temperature
The CHEM-REZ System...
Pioneered by
Archer-
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A-D-M
for Technical Bulletin
on
CHEM-REZ



A Significant NEW

NO·BAKE Binder

→ For Production and Semi-Production

→ For Cores and Molds in Iron, Steel and Non-Ferrous Casting

NO ODOR • COMPLETE COLLAPSIBILITY • MAKE AND DRAW CORE BOXES—While new to this country, *CECO-SET* is thoroughly proved effective in actual foundry practice. Remarkable economies, together with improved casting quality are achieved through use of *CECO-SET*. Minimum hand ramming is required, a long sand life is assured, there is less gas in the core—with no obnoxious smoke during pouring.

Ask for Bulletin CS-1 or see us at the AFS Castings Exposition—at the booth with the Flowering Poplar Tree.

PRODUCTS FOR FOUNDRY PROGRESS

G. E. SMITH, INC.

246 Washington Road Pittsburgh 16, Pa.

Distributors: Core-Lube, Inc., Danville, Ill. • Klein-Farris Co., Inc., Boston, Mass. • Sierra Foundry & Supply Co., San Gabriel, Calif. • George F. Pettinos (Canada) Limited, Hamilton, Ontario

Circle No. 128, Page 207

Circle No. 129, Page 207

pouring off the heat

As Mayor of the City of Philadelphia, I am delighted to extend a warm and cordial welcome to the 64th AFS Castings Congress and Foundry Show.



Your organization could not have selected a more suitable site for your annual meeting. Philadelphia, as the Workshop of the World and heart city of the vast Delaware Valley industrial complex, is one of the largest producers and users of castings.

We are happy to be your host. We hope that your members and exhibitors will enjoy their visit to the fullest and that their stay here will be a pleasant and profitable one. I am sure that the hospitable people of our city will do their utmost to help make it so.

Richard Dilworth
Mayor
City of Philadelphia

Canadian thanks

■ It was with considerable interest that I read the February issue of MODERN CASTINGS which was dedicated to the Canadian metalcasting industry. You and your staff have certainly done an excellent job. I am sure that all the Canadian readers appreciate this gesture.

A. J. Moore
Canadian Bronze Co. Limited
Montreal, Que.

■ A considerable amount of interest has been expressed in Canada on the recent edition of MODERN CASTINGS which gave most of the editorial section to Canadian foundries.

You are certainly to be congratulated on this edition which was most excellently presented. The AFS members here in Canada are generally well pleased and at long last have a great feeling of belonging.

Canada and Canadian foundrymen have a wealth of experience, articles and stories which they would like to present to the International Membership. We look forward to a repeat of your recent publication. Any help which the public relations committee of the Ontario Chapter can give, please do not hesitate to let us know.

Vincent H. Furlong
Public Relations Chairman
AFS Ontario Chapter
Oakville, Ontario

■ I wish to congratulate you on a job very well done for this special Canadian

Continued on page 16

exciting news
at the G. E. Smith Exhibit
Booth 1228
AFS 64th Annual Castings Congress & Exposition, Philadelphia

new NO-BAKES

KOLD-KURE
For jobbing type core production—a new companion product to Kold-Set.

CO-SET
For production and semi-production core making. Also, for use as a no-bake mold facing.

new WASHES

KOLD-KOTES—Developed primarily for use with *no-bake* and Kold-Set processes. Also for use in coating cores and molds made with conventional core-oil, resin, CO_2 and other binders.

Type S—for Steel Castings
Type G—for Iron and Non-Ferrous Castings

new DATA

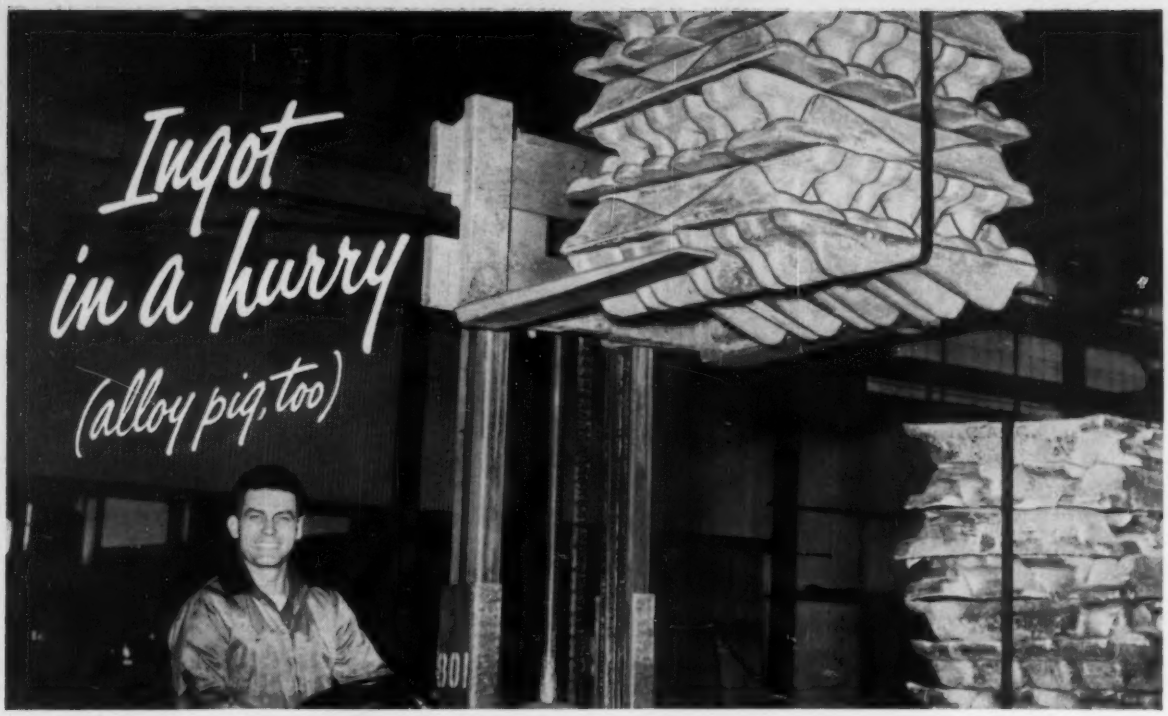
- Zircon Washes
- Activators
- Kold-Set Facing Mix
- Feox Sand Additive

FOUNDRY TOUR
Join us in a tour of Atlantic Steel Foundry to see KOLD-KURE and KOLD-SET in Production Use.
Write or phone for a reservation.

FOR FOUNDRY PROGRESS PRODUCTS

G. E. SMITH, INC.
246 WASHINGTON ROAD
PITTSBURGH 16, PA.

Warehouse Stocks in Boston • Chicago • Philadelphia • Detroit • Indianapolis
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...get fast delivery on any aluminum alloy pig or ingot from your REYNOLDS INGOT DISTRIBUTOR

The old cliche, "time is money" really hits home when your casting operation is held up for want of metal. But if that metal is aluminum, there's no problem. Just call your local Reynolds Ingot Distributor.

Chances are, the metal you need—in the right alloy and size will be at your doorstep in 24 hours or less from your Reynolds Distributor's stock. Or he can get you any casting alloy for prompt shipment from Reynolds plant inventory.

Your Reynolds Ingot Distributor is geared to deliver the pig and ingot you need *fast.* Call him.

Reynolds Metals Company, P.O. Box 2346-FL, Richmond 18, Virginia.

REYNOLDS INGOT DISTRIBUTORS

Abasco, Incorporated, P. O. Box 13367, Dallas 20, Texas • **American Alloys Corp.,** 4446 Belleview, Kansas City, Mo.
Atlas Metal Co., 8550 Aetna Road, Cleveland 4, Ohio • **Barth Smelting Corp.,** 99-129 Chapel Street, Newark, N. J.
Bay State Refining Co., 8 Montgomery Street, Chicopee Falls, Mass. • **W. F. Jobbins, Inc.,** North Lake Street Rd., Aurora, Ill.
Morris P. Kirk & Son, Inc., 2700 S. Indiana St., Los Angeles, Calif. • **Milward Alloys, Inc.,** Lockport, N. Y.
Milwaukee Chaplet Co., 8656 West National Ave., Milwaukee, Wisc. • **Richards Corporation,** 356 Commercial St., Malden, Mass.
Sipi Metals Co., 1720 N. Elston Ave., Chicago 22, Ill. • **Sonken-Galamba Corporation,** 2nd and Riverview, Kansas City, Kansas
Nathan Trotter & Co., 36 N. Front Street, Philadelphia 6, Pa.

REYNOLDS ALUMINUM

Watch Reynolds TV shows—**"ALL STAR GOLF", "ADVENTURES IN PARADISE"** and **"BOURBON STREET BEAT"—ABC-TV**

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

Circle No. 130, Page 207

CORE HARDENING TIME CUT

from 3 hours to 15 seconds*

...WITH PURECO CO_2 "FLASH CURING"



The Pureco CO_2 *Flash Curing* process can mean extensive savings in time and money to you. Hardening time is cut from hours to seconds . . . no costly baking ovens or core driers are needed . . . valuable space is saved . . . more accurate castings with smoother finish result. Mold drying is eliminated . . . rapid production of finished cores expedite rush orders. In-plant handling time is drastically reduced.

For production or custom work.

Pureco can tailor a *Flash Curing* installation to meet your specific foundry requirements —large or small. Cost is low—installation simple.

Have a trial Flash Curing demonstration.

Pureco would like to demonstrate its *Flash Curing* process in *your foundry* under *your working conditions*, with no obligation on your part. Call your local Pureco man or write:

**Actual Pureco test*

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PURECO CO_2

PURE CARBONIC

Pure Carbonic Company, A Division of Air Reduction Company, Incorporated
Nation-Wide Pureco CO_2 Service-Distributing Stations in Principal Cities
General Offices: 150 East 42nd Street, New York 17, N.Y.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT

Circle No. 131, Page 207

Continual research confirms:

there's nothing like *solid* Quality

CHILL KOOLHEAD NAILS



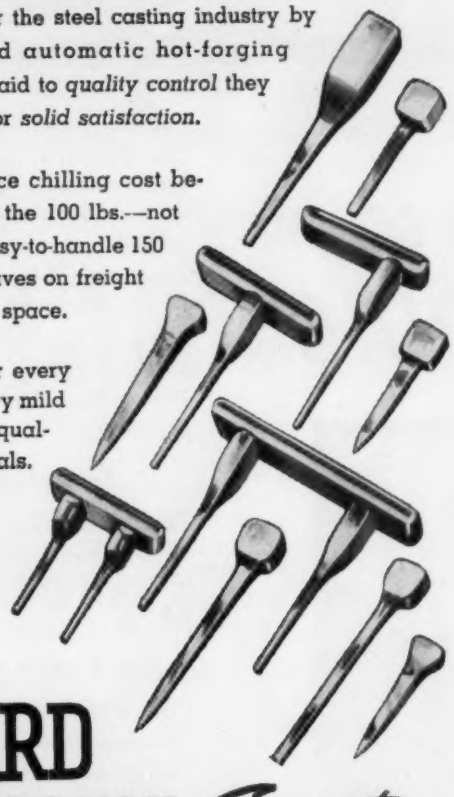
...they're solid boss—

S-O-L-I-D

Over the years we've made and tested various types of FOUNDRY CHILLS . . . Foundries always tell us that our *solid* nail-type chills are *best.* "KOOLHEAD" Chill Nails and Spider Chills are made especially for the steel casting industry by our patented automatic hot-forging method. As an aid to *quality control* they fuse completely for *solid satisfaction.*

"KOOLHEADS" reduce chilling cost because they're priced by the 100 lbs.—not by the piece. Packed in easy-to-handle 150 lb. and 50 lb. cartons . . . saves on freight . . . saves up to 30% floor space.

A size and shape for every chilling job. Made from very mild low carbon "KOOLHEAD" quality steel rod and other metals.



Write for descriptive folder and price list

STANDARD HORSE NAIL Corporation

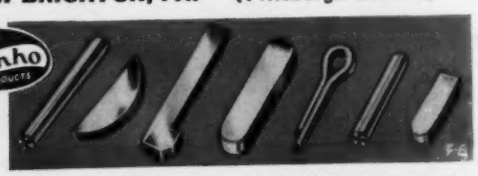
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Other Products

PINS • KEYS

SPECIAL PARTS



64th Castings Congress and Foundry Exposition, Philadelphia, May 9-13.

Visit Our Booth No. 520, Convention Hall

Circle No. 132, Page 207

Pouring off the Heat

Continued from page 13

issue. It is always comforting to realize that not only Canadians are aware of our know-how and potentiality in this field.

J. M. Rochon
Chief, Metals & Minerals Division
Foreign Trade Service
Ottawa, Ont.

■ The "Canadian issue" of MODERN CASTINGS, February 1960, was very well received by the membership of the AFS British Columbia Chapter.

At a recent meeting of the directors, I was instructed to express the interest of the Chapter in this issue and the feeling of participation encountered. We think that the feeling of participation might be further fostered by a small Canadian section in each issue where local Chapter and foundry news could be readily found.

A. W. Greenius, *Secretary-Treasurer*
British Columbia Chapter, AFS

casting raisers

■ I read and enjoyed your article "Our Manpower Bottleneck" by H. F. Dietrich, p. 139, January, MODERN CASTINGS. You have the ability to present a serious problem in amusing manner.

However, I can't believe that you are really serious. In an age that is selling America on the need for high-powered technicians, and highly skilled workers, I'm glad to know that some of my "low-powered" boys can qualify as "Left Side Casting Raisers." No one else wants these boys. The colleges, the tech schools, the apprentice programs—all want the best. I'm sure that industry is fostering a two class society: technical giants and casting raisers. If this trend continues, and if automation progresses, we will eventually have instead, technical giants and unemployed laborers.

We have many boys with low IQ's and always will have. You keep the job open. I'll keep it filled.

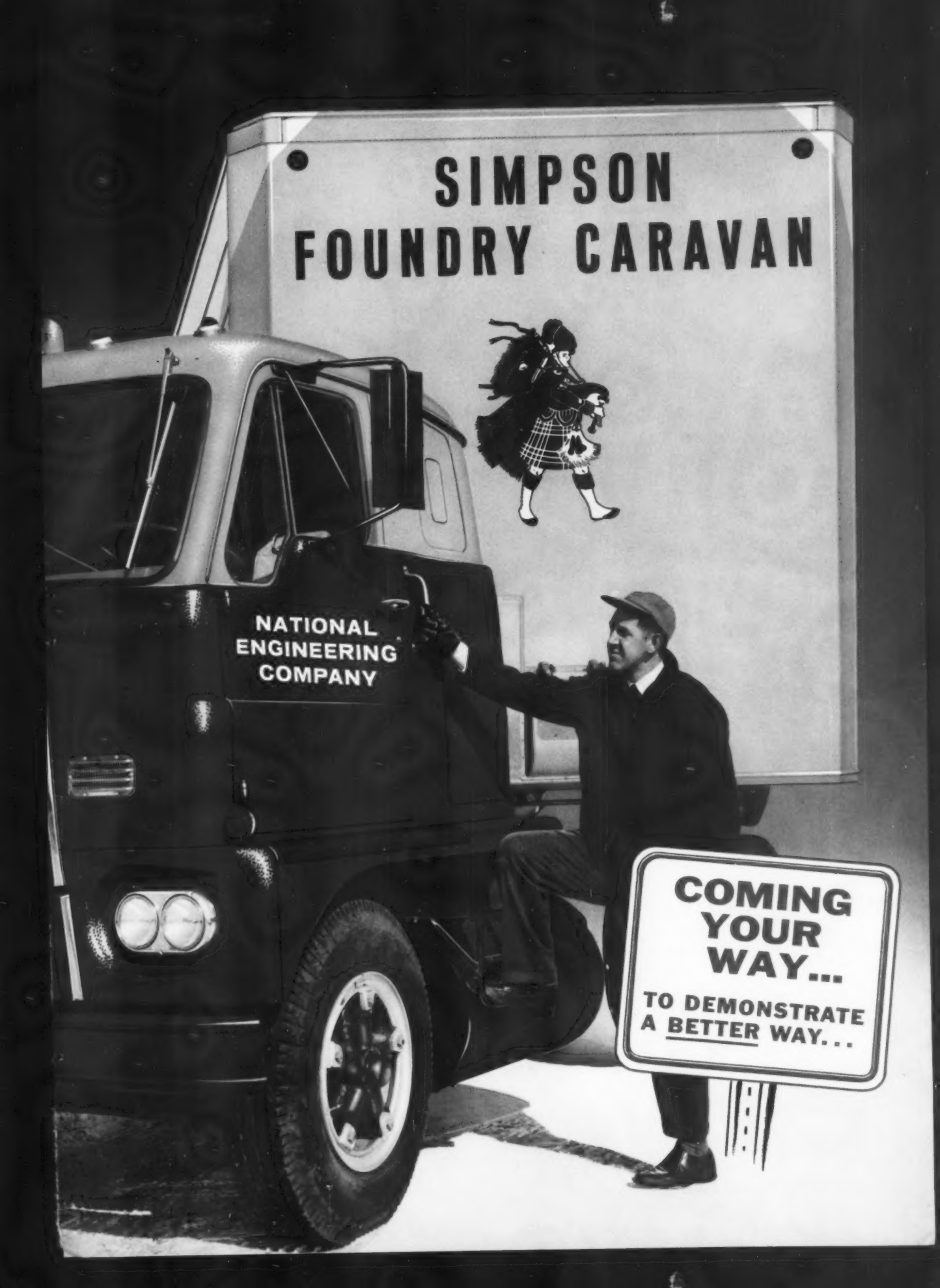
John Bogner
Guidance Department
Charlotte Public Schools
Charlotte, Mich.

■ Mr. Bogner's concern for the future of his "low-powered" boys is commendable. However, the prerequisite for the position of Left Side Casting Raiser is that the applicant completed the course in "Waving Bye, Bye" before he is age 32. Anyone with an education higher than this would surely be unhappy with that job.

Anyway, Lincoln had very little formal education, Henry Ford Sr. didn't get through high school, and Tom Edison was kicked out of sixth grade. When evaluating our younger generation, who can say, "Archibald will be a nuclear physicist and Herkimer will be a pick and shovel jockey"? It could very well turn out that Archibald will

Continued on page 23

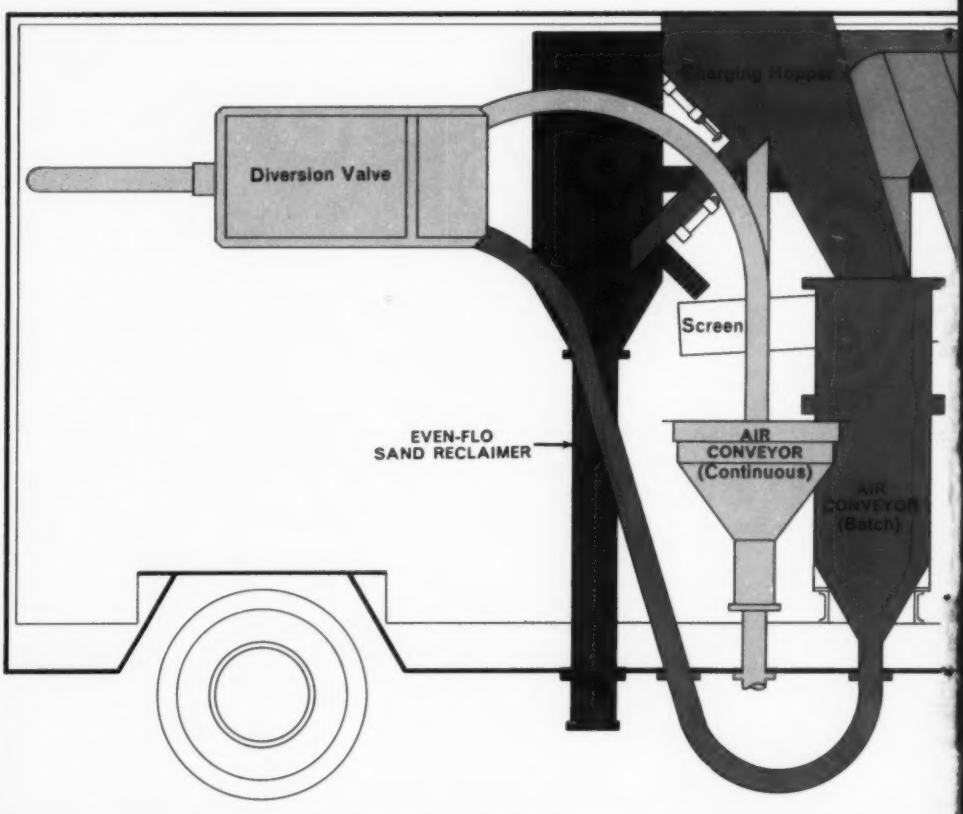
Circle No. 205, Page 207


SIMPSON
FOUNDRY CARAVAN
NATIONAL
ENGINEERING
COMPANY
COMING
YOUR
WAY...
TO DEMONSTRATE
A BETTER WAY...

NATIONAL

- SHELL-MULL
- MULTI-MULL
- COOLEVAYOR
- AIR-CONVEYOR
- EVEN-FLO RECLAIMER





HITS THE ROAD IN 1960

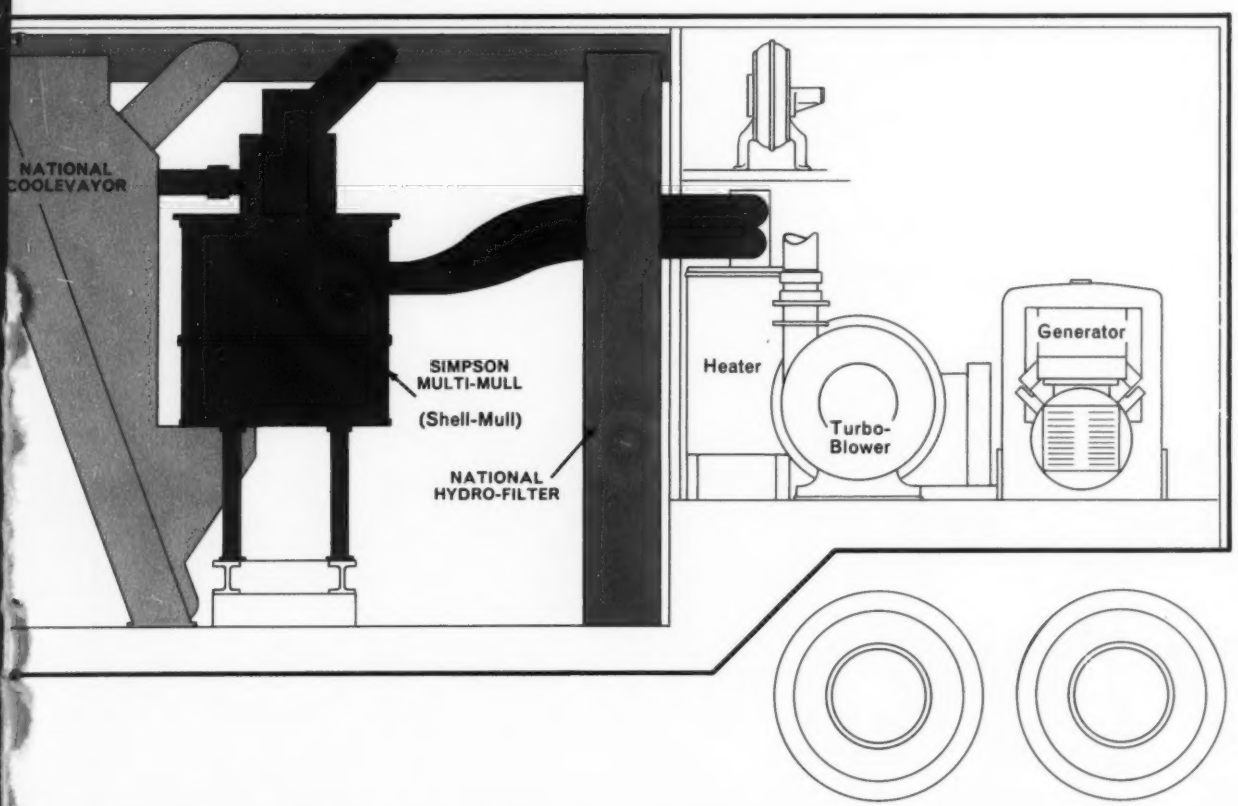
TO DEMONSTRATE THE LATEST FOUNDRY EQUIPMENT AND TECHNIQUES FOR: ■ SHELL MOLDING ■ MIXING ■ SAND COOLING ■ PNEUMATIC TRANSPORT ■ SAND RECLAIMING

The Simpson Foundry Caravan is not an exhibit, not a show or movie. It is a full-scale sand conditioning pilot plant. Into this 37 foot trailer, National has incorporated a full size operating plant which includes the latest in National production and processing equipment.

The Caravan was designed and built to demonstrate . . . at *your* plant, with *your* sand . . . exactly how you can expect to improve the quality of your sand and increase the profitability of your foundry operation through the use of any one or all of these equipment items.

We invite you to be our guest during our stay in your area. The program is informative, instructive, and planned so that *you* can benefit from the experience which other foundries have had with this equipment.

For further details, on the Simpson Caravan and equipment, please return the card attached.



NATIONAL SHELL-MULL

For Controlled Coating

Consists of pre-heater, Simpson Multi-Mull, Coolevayor and screen. New Multi-Mull continuous mixer speeds up mixing time . . . insures most thorough and controlled mulling action available for resin-bonded formulas. Shell-Mull system affords:

- Uniform controlled coating
- High tensiles with low resin usage
- Low equipment costs
- Controlled hot air addition



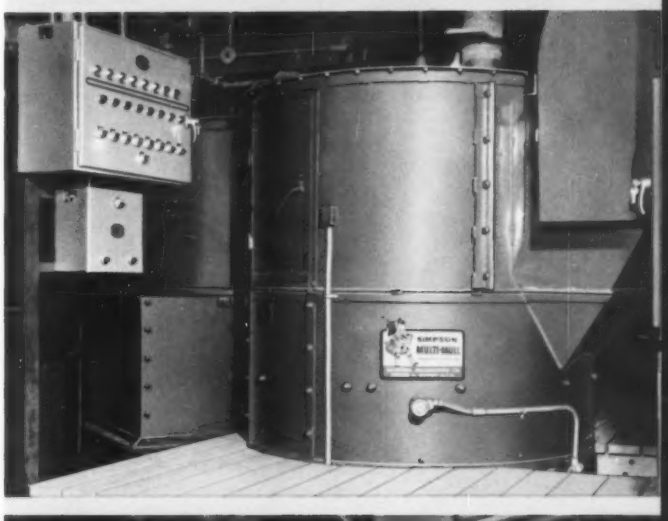
Hood equipped for air exhaust insures safety and provides quick access for charging and maintenance

SIMPSON MULTI-MULL

The only continuous muller!

This unique, high production unit lets you *mull* all the system sand you need *continuously*. It's National's 1960 *answer* to high production *plus* better, more uniform and more accurately controlled system sands. See these features demonstrated:

- High volume in small space
- Eliminates batching, mill hoppers and belts
- A size for every foundry need and purse



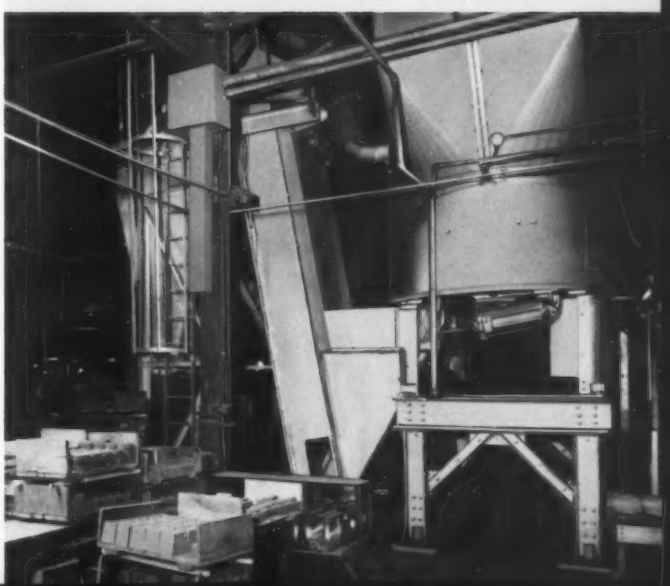
Multi-Mull at eastern foundry replaced pug mill. Occupies same floor area and space . . . with considerable increase in sand tonnage per hour.

NATIONAL COOLEVAYOR

Lets you cool as you elevate and distribute!

Fast, efficient and compact, this unit cools and aerates a full charge from a mixer as it elevates and distributes sand to storage. Temperature drops from 200°—to within room temperature are possible.

- Use it as an elevator
- Use it as a conveyor
- Use it in *any* system

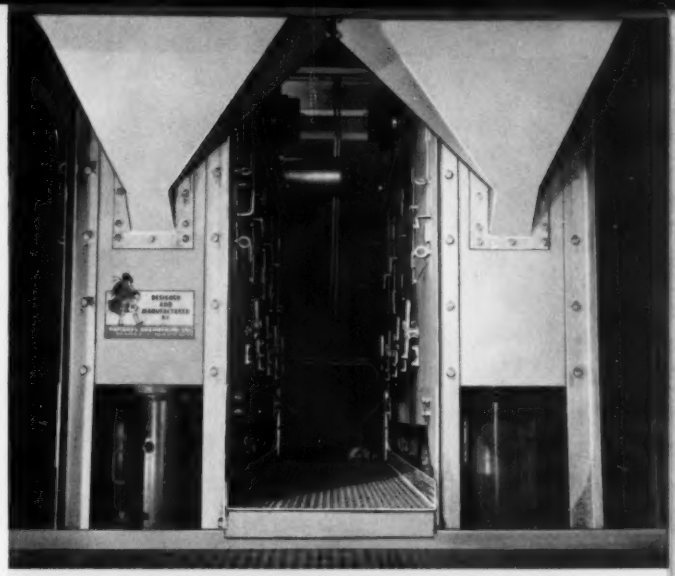


NATIONAL EVEN-FLO SAND RECLAMATION SYSTEM

Pneumatic reclamation within the reach of every foundry.

Typically simple in design and operation, this system has no moving parts . . . only one wear part. Thoroughly proven in over 60 foundry installations where it has reduce new sand costs up to 80%, and:

- *Improves* quality and workability of sand
- Turns in *annual* savings of between $30,000 and $100,000
- Operates continuously without supervision, little maintenance
- Sold under performance guarantee
- Can reduce or eliminate waste sand haulage and disposal
- Handles *any* type of foundry sand

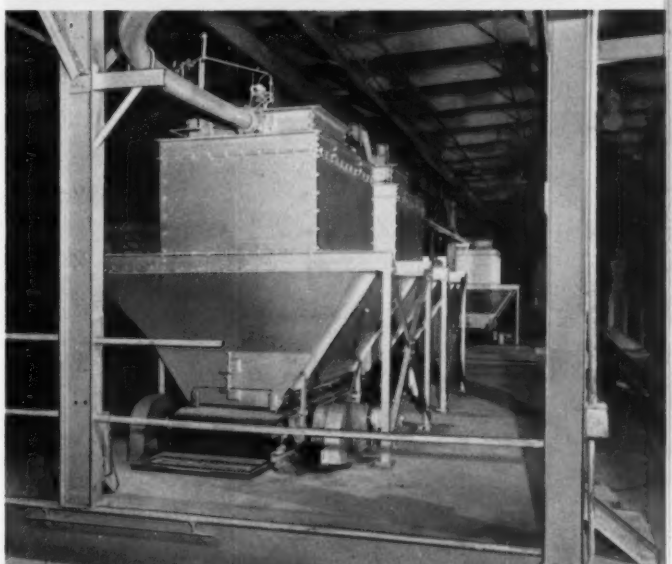


NATIONAL AIR CONVEYOR
(batch type)

For fast, flexible pneumatic transport of materials throughout the foundry.

Pilot unit demonstrates the competent engineering and the latest National-patented components which make the National System efficient and trouble free:

- Two-way diversion valves
- Easy-open couplings
- No moving parts in Baffle Box
- Foundry experienced layout and engineering services
- Full follow-through for erection, parts and service

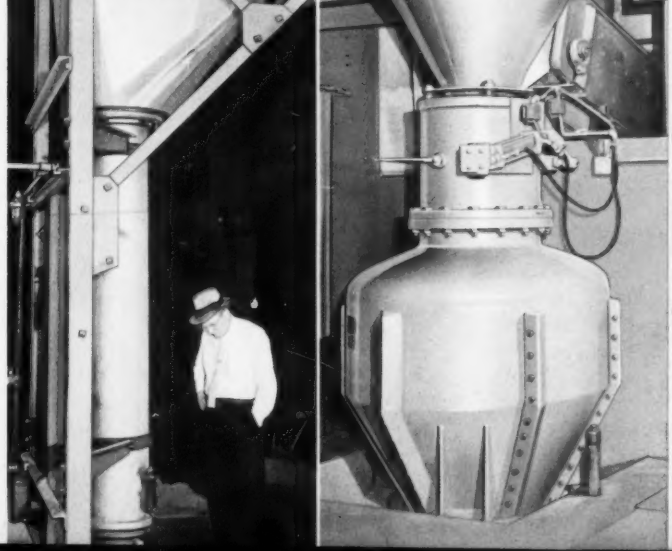


NATIONAL AIR CONVEYOR
(continuous type)

Low cost system automates sand delivery and distribution.

This simple and completely versatile low cost system saved Studebaker Corp. foundry $12,950 in time, labor and maintenance costs in one year of operation.

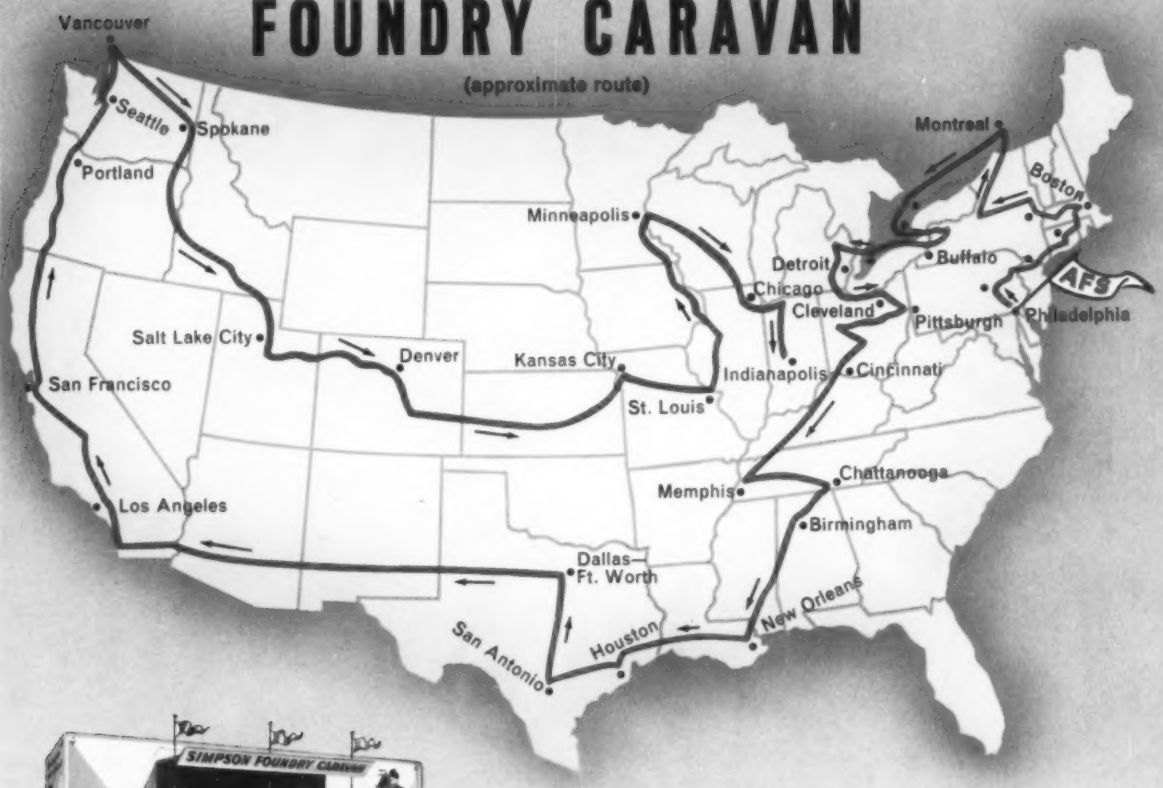
- No moving parts, except blower
- Fully automated, continuous operation
- Occupies less than half the space of conveying equipment and elevators for equivalent work



Photos show: (1) System discharging to mill belt serving four refractory brick presses, (2) Compact, continuous transporter at Studebaker Corporation, (3) Batch system transporter handles 40 cu. ft. of granular bonded material per batch via versatile, minimum headroom "pipeline routing."

SIMPSON FOUNDRY CARAVAN

(approximate route)





The most complete sand conditioning pilot plant on wheels

The National Caravan is completely self-contained in a 37 foot, generator-equipped trailer. The program includes a 15-minute "briefing"-showing equipment in use followed by demonstration of specific items of equipment using sand supplied direct from "host" foundry.

Stops in key foundry locations have been scheduled to permit a maximum number of foundrymen to see and make use of the equipment on their own materials.

The Caravan is staffed with competent engineers and technical personnel. All tests will be conducted under controlled conditions and a report submitted. Your local National representative will be in attendance to welcome you, to supervise equipment demonstrations and to help evaluate sand tests.

Return the card for further details.

DEMONSTRATIONS IN THESE KEY FOUNDRY CITIES

Philadelphia, Pa.
Eddystone, Pa.
Hamburg, Pa.
Reading, Pa.
Emmaus, Pa.
Bethlehem, Pa.
Phillipsburgh, N.J.
Hillside, N.J.
Harrison, N.J.
Branford, Conn.
Hartford, Conn.
Providence, R.I.
Hopedale, Mass.
Boston, Mass.
Worcester, Mass.
Springfield, Mass.
Pittsfield, Mass.

Albany, N.Y.
Schenectady, N.Y.
Syracuse, N.Y.
Montreal, Quebec
Toronto, Ontario
Hamilton, Ontario
St. Catharine's, Ontario
Rochester, N.Y.
Buffalo, N.Y.
Sarnia, Ontario
Saginaw, Michigan
Flint, Michigan
Detroit, Michigan
Ann Arbor, Michigan
Toledo, Ohio
Cleveland, Ohio
Pittsburgh, Pa.

Canton, Ohio
Massillon, Ohio
Mansfield, Ohio
Lima, Ohio
Columbus, Ohio
Cincinnati, Ohio
Memphis, Tenn.
Chattanooga, Tenn.
Birmingham, Ala.
New Orleans, La.
Houston, Texas
San Antonio, Texas
Dallas—Ft. Worth
San Diego, Calif.
Los Angeles, Calif.
Fresno, Calif.
Oakland, Calif.

San Francisco, Calif.
Portland, Oregon
Tacoma, Wash.
Seattle, Wash.
Vancouver, B.C.
Spokane, Wash.
Salt Lake City
Provo, Utah
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Pueblo, Colo.
Kansas City, Mo.
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Chicago, Ill.
South Bend, Ind.
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NATIONAL ENGINEERING COMPANY
549 West Washington Blvd.
Chicago 6, Illinois

Printed in U.S.A.

Pouring off the Heat

Continued from page 16

be a beatnick, while Herkimer will become the highest paid alumnus of the manual training class.

H. F. Dietrich
Kansas State University
Manhattan, Kan.

■ I want to thank those readers who took the time to write to the editor about my article, "Pattern Engineering", which appeared in the November issue of MODERN CASTINGS.

Their writing showed their interest in the subject, and their comments strengthened my opinion that a problem exists. By being aware of the problem we can make some progress toward solving it. I am not convinced, however, that any set of specifications can cover all types of patterns any more than one set of specifications can cover all types of buildings or all types of machines. I am glad to know that the AFS Pattern Division is concerned with the situation.

I want to thank the editor for his encouragement and counsel in the preparation of this article.

P. B. Croom
Houston Pattern Works
Houston, Texas

■ I am Midshipman First Class at the U. S. Naval Academy in the process of writing a term paper on the importance of sand in the production of light bronze castings. I was told by numerous sand and bronze foundry employees that your magazine MODERN CASTINGS contains a wealth of information that would be of interest to me. The Academy library does not have a file of the past issues of that periodical and I'm fairly restricted in my movements. I was wondering if you could send issues of previous magazines that might contain articles on the above subject to me. Thank you.

R. William Lloyd
U. S. Naval Academy
Annapolis, Md.

design symposium

■ The Casting Design Symposium described in your January issue of MODERN CASTINGS is certainly a worthwhile project. Our company has a little different approach. We hold two meetings a year on foundry procedures, new developments, design, costs and other subjects related to foundry operations. The personnel that attend such meetings have something to do directly or indirectly with the subject and are picked by each individual plant management.

Incidentally, our local AFS Quad City Chapter carried on an extensive six-week program in 1957 in the same manner outlined in the article. Our attendance at these sessions started with 200 people. At the close of this course we had lost only eight. Conferences were conducted during the spring of the year and com-

Continued on page 28



★ You Get Cleaner Iron
★ Castings With Better Machinability
★ Greatly Increased Slag Flow Off
★ Cupola Maintenance Costs Reduced

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IF you melt aluminum, copper or brass, try Famous Cornell Aluminum, Copper or Brass Flux. Write for Bulletin 46-A.

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BOOTH 1504

FAMOUS CORNELL FLUXES

The CLEVELAND FLUX Company
1026-40 MAIN AVENUE, N.W. • CLEVELAND 13, OHIO
Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

Circle No. 133, Page 207

Circle No. 285, Page 207
Circle No. 134, Page 207

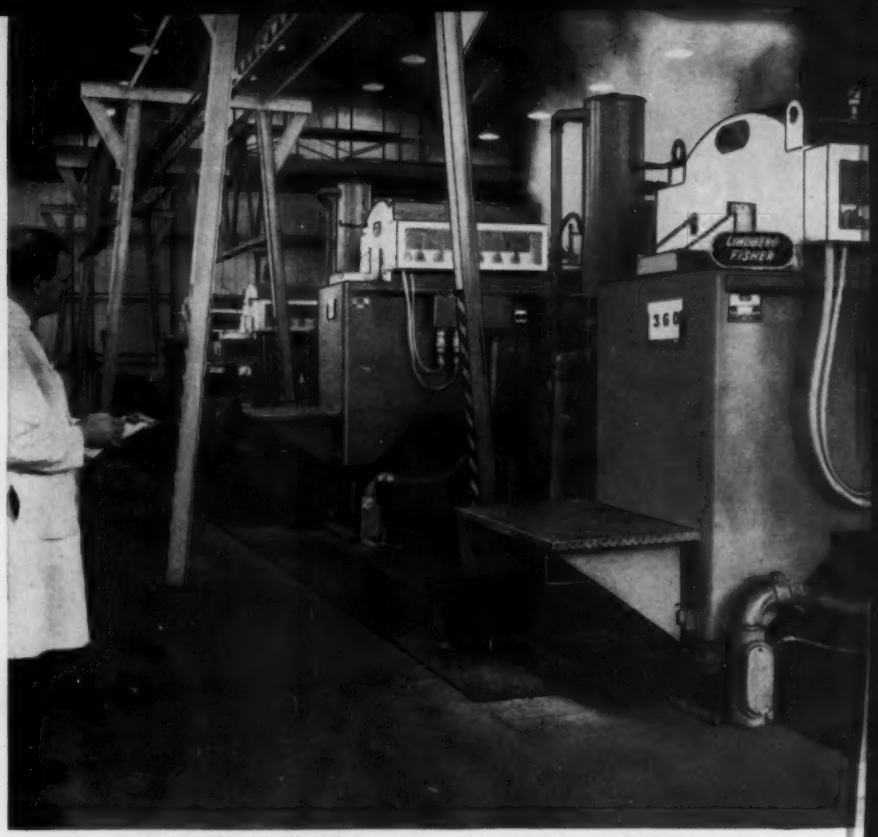
When you apply heat to aluminum Lindberg can give you the right help

If your product requires the application of heat to aluminum, you can safely look to Lindberg for the equipment and methods to do the job best. Anywhere along the line from the ingot to the finished product, Lindberg-Fisher equipment and broad experience can meet every need.

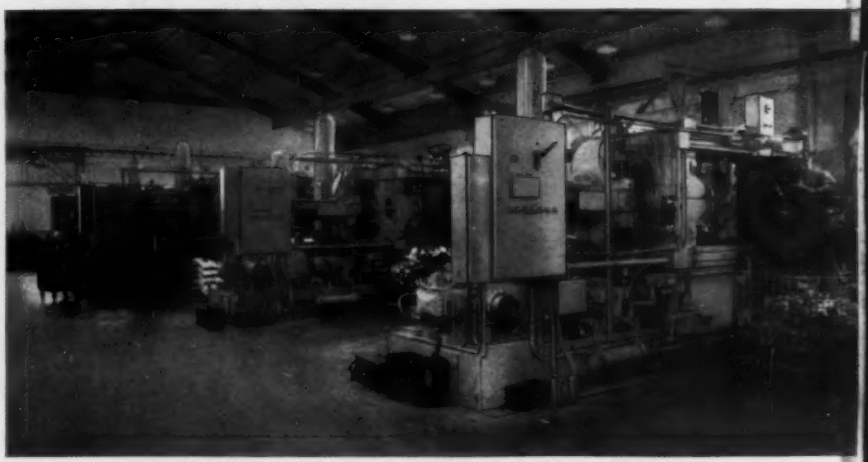
With its long-time background in all phases of heat to industry our engineering staff has standout knowledge of the hows and whys of aluminum melting, casting and treating. Over the years this staff has been responsible for many of the most important developments in the field.

For instance, the technique of putting a cast lining in induction melting furnaces to provide lower initial and maintenance cost . . . the Lindberg Autoladle, the first practical automatic ladling unit . . . the two-chamber induction melting furnace . . . and many other practical innovations. This is why our aluminum processing experts, such as Ray Dunn are frequently consulted in an advisory capacity on aluminum treating problems.

Since we cover all types of equipment for melting, holding or treating aluminum, you can depend upon us to recommend objectively the most suitable procedures and equipment to fit your requirements. Get in touch with your local Lindberg Field Engineer (see your classified phone directory) or write direct to: Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard St., Chicago 12, Ill.



Line-up of four Lindberg-Fisher electric resistance reverberatory holding furnaces at McCulloch Corporation. Die casting machines are just behind each furnace.



Line-up of four die casting machines at McCulloch Corporation. Lindberg-Fisher Holding Furnaces are just behind each machine.

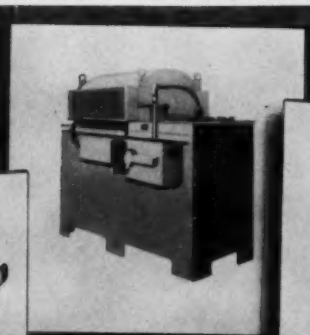
THERE'S LINDBERG EQUIPMENT FOR EVERY INDUSTRIAL NEED

These are representative units from complete Lindberg lines in all types of industrial heating equipment.



The Lindberg Autoladle





Electric Resistance Aluminum Holding Furnace

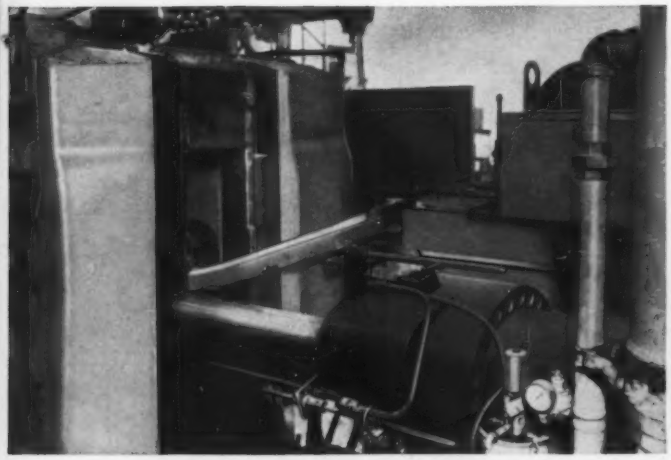
Cyclone Heat Treating Furnace



THE RIGHT COMBINATION FOR DIE CASTING EFFICIENCY...LINDBERG FURNACES AND AUTOMATIC LADLING

Die casting efficiency at the McCulloch Corporation, Los Angeles, California, has been gratifyingly increased with the new installation of four Lindberg Electric Resistance Reverberatory Holding Furnaces equipped with Lindberg's automatic ladling unit, the Autoladle. These holding furnaces, with 2000 lbs. molten aluminum capacity, are spotted adjacent to four die casting machines. Molten aluminum is delivered to the furnaces by monorail and held at the precise temperature required by the casting station. The precise shot is delivered automatically to the die casting machine by the Lindberg Autoladle. This installation is used primarily for casting parts for McCulloch-Scott outboard motors.

In any production process where aluminum needs heat there is Lindberg equipment to apply it most economically and efficiently, and Lindberg experience to fit this equipment most ideally to your product and production requirements. Furnaces for melting and holding, casting stations, re-melting or heat treating are available in all capacities, electric or fuel fired. Get in touch with your Lindberg Field Engineer (see your classified phone book) or write us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Ave., Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

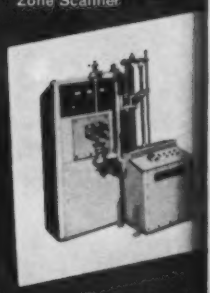


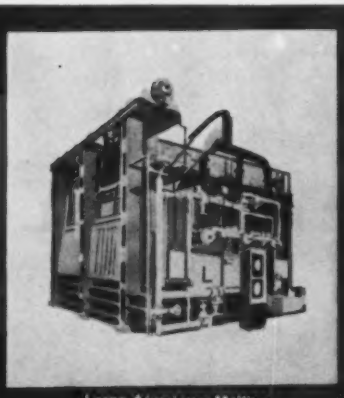
Precise shot of proper temperature aluminum is automatically delivered from conveniently located holding furnace to die casting machine by Lindberg Autoladle.



Housings for McCulloch-Scott outboard motors, shown here, are representative of the type of castings Lindberg equipment helps McCulloch produce.

High Frequency Unit with Zone Scanner





Large Aluminum Melting and Holding Reverb.

Laboratory Box Furnace





Periodic Ceramic Kiln



350 KW Induction Melting Furnace

Stop at booth 928



Visit BAROID CHEMICALS at the AFS exposition . . .

PETRO BOND* will be featured in an operating foundry at Baroid Chemicals' AFS Exhibit. You'll see the smoother finishes, the more faithful pattern reproduction obtainable with this outstanding sand-bonding agent.

PETRO BOND is a formulated sand-bonding agent used with oil instead of water. PETRO BOND produces precision castings with conventional foundry equipment. Castings are sounder . . . with less porosity . . . surfaces are denser, tolerances closer.

In addition to the operating foundry,

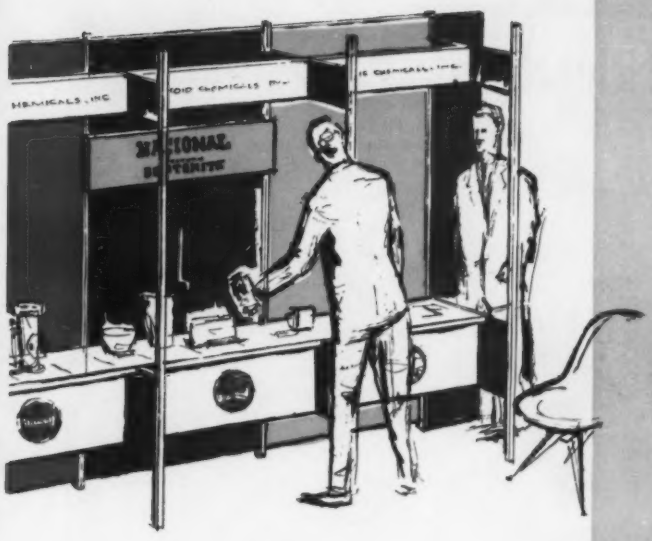
BAROID

BAROID CHEMICALS, INC.
A SUBSIDIARY OF NATIONAL LEAD COMPANY

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Circle No. 135, Page 207

Circle No. 134, Page 207



there will be a display of castings produced in PETRO BOND sand showing the wide utility of the product.

NATIONAL® Western Bentonite in molding sands produces fine finish castings of all metals — malleable iron, gray iron, steel, brass, aluminum or magnesium. NATIONAL Western makes better cores and high-refractory wash formulations. NATIONAL cores dry faster, have higher dry strength and contain less gas to vent.

Be sure to visit Baroid Chemicals' Exhibit at the 1960 AFS Castings Congress and Exposition in Philadelphia, May 9-13.

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Better castings through BAROID RESEARCH

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Metal is melted in gas-fired, crucible-type furnace at Baroid Chemicals' Pilot Foundry.



Test molds are compacted in the jolt-squeeze molding machine at right. Thermolab for high temperature sand testing is at left.



Sand testing equipment includes, from left to right: sand rammer, universal strength machine, permeability tester.



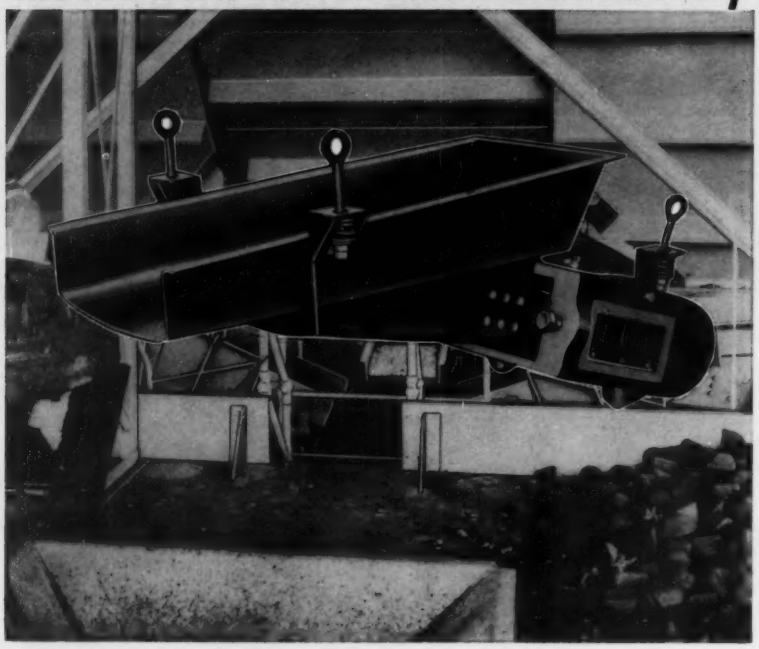
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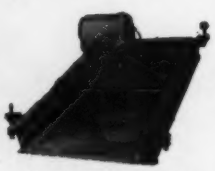


TEST SIEVE SHAKERS



VIBRATING CONVEYORS

Circle No. 136, Page 207



VIBRATING SCREENS

Pouring off the Heat

Continued from page 23

peted against the local and state basketball tournaments.

M. H. Horton
Materials Engineering Dept.
Deere & Co.,
Moline, Ill.

■ My membership in AFS and work with the Northwest Regional Conferences have given me opportunity to make a great many friends with the Canadian foundry personnel. It was a pleasure to see the February issue devoted to the Canadian foundry industry.

I was quite disappointed, however, to note the omission of the ESCO Limited foundry at Port Coquitlam, B.C. We are wondering if there was some reason for not including ESCO Limited under the categories of stainless, centrifugal and alloy steel foundry listings. ESCO Limited, which is our Canadian affiliate, has built a modern foundry and the first heat was poured on Feb. 28, 1958.

I certainly hope you will add ESCO Limited to your list of Canadian foundries and, if possible, include the ESCO Limited foundry in any lists which may be published in the future.

Norman E. Hall
Electric Steel Foundry Co.
Portland, Ore.

Our omission was entirely inadvertent. The list of foundries published in MODERN CASTINGS *was prepared by the Canadian Foreign Trade Service. We alerted them to this oversight and presume ESCO will be added to their Trade Index.*

■ The "Casting Design Symposium" article in the January issue of MODERN CASTINGS was encouraging to read. We are also planning a casting symposium for customers sometime this year. We plan to cover other facets than design, such as metallurgy, patternmaking, terms and conditions of sale, etc.

The value of planned programs for educating employees or customers and prospective customers should not be underestimated. There is nothing like visual aids and personal contact in presenting any subject. In other words, if a group of people are brought together, the job of educating them is much, much easier and tremendously more efficient.

Peter Robert Rentschler
Vice-President
Hamilton Foundry, Inc.
Hamilton, Ohio

■ Your article in the April issue of MODERN CASTINGS on the quantitative breakdown of the material handling aspects for a ton of marketable castings is excellent. Congratulations.

G. E. Seavoy, *Vice President*
Whiting Corp.
Harvey, Ill.

In iron foundries today the trend is to...

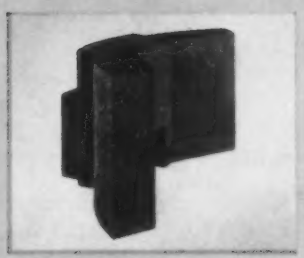


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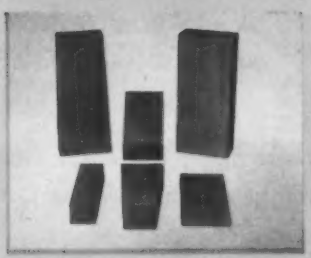
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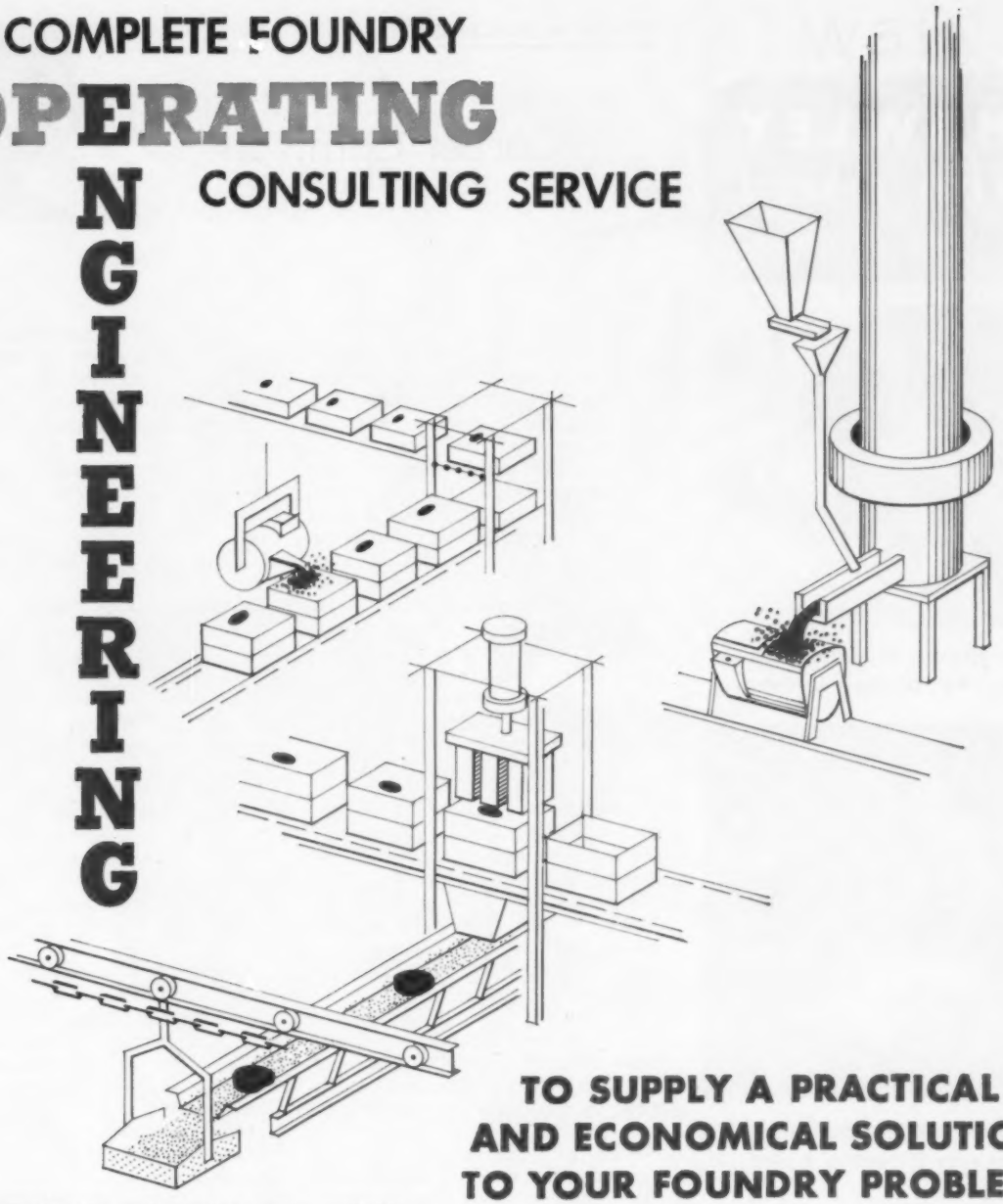
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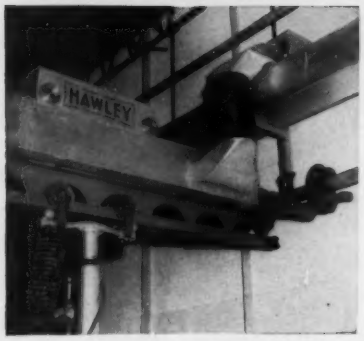
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Circle No. 142, Page 207

Career Carnivals



by RALPH BETTERLEY

What is a Career Carnival? Perhaps a Career Exhibit, Occupation Night or some similar title might best describe this project. Basically, it is a planned exhibit of occupations, professions and job opportunities existing in our major fields of endeavor. These carnivals are displays, usually organized by city and/or school districts in cooperation with local industry, the chamber of commerce and other civic organizations. Student groups from the schools are scheduled for specific carnival visiting periods and the exhibits may be open from one to several days. Some carnivals operate evening periods to accommodate interested parents who wish to discuss careers in the company of their children. Attendance may go into the thousands.

Foundrymen are becoming increasingly cognizant of the need for training and recruitment in their basic industry. So here's an opportunity for the foundry industry to 'sell its wares" at such a display. Foundry management would, therefore, be amiss not to take advantage of the informative opportunities possible.

Beyond this, however, the industry should not overlook the fact that these students, as well as their parents, are potential customers of castings. Career Carnivals, without question, provide an excellent medium to educate and interest "new blood" in the foundry industry, notwithstanding the improved public relations which are possible through well-organized participation. A plant or plants can organize suitable exhibits; however, this project can be handled best by the Educational Committee of the local AFS Chapter.

What can be done at these exhibits? Exhibits utilize literature, charts, demonstrations, models, job descriptions, movies, lectures, sample products and discussion. The type of activity, or display, will have great bearing on the interest created. Demonstrations showing processes with quick results and broad applications have little difficulty in getting the desired results. This is a natural for foundries as the pre-requisites for maximum interest are there. Produce a working exhibit portraying some of the interesting facets of castings production. It was not difficult for the AFS Wisconsin Chapter to attract attention one cold day last winter when castings were poured on the sidewalk in downtown Milwaukee. (See April issue of MODERN CASTINGS.)

Some local AFS Chapters have been very active with Career Carnivals. The National AFS office has in several instances worked with these groups—supplying literature, films and assistance in exhibit planning. They stand ready to assist other chapters. April 27, Central Indiana Chapter, exhibited at the "Kokomo Career Exhibit." This event, organized by the Chamber of Commerce and the school system, was viewed by 2,500 to 3,000 students. At the Flint, Michigan, carnivals excellent foundry displays have been organized and manned by Central Michigan Chapter members. The Foundry Club of General Motors Institute also made noteworthy contributions to the success of these exhibits.

Highlighting one of the carnivals was a demonstration of molding and pouring small castings using oil-bonded sand and low-melting lead-base alloys. This exhibit attracted wide attention and clearly portrayed the basic casting process. Small kits are now commercially available and would be ideal for use in future carnivals.

A committee of the AFS Education Division is presently developing foundry guidance literature for such carnivals. As soon as available, the national office will supply this material and additional assistance for local chapters.

Education is a comprehensive and broad field. It is no surprise, therefore, to find educational opportunities in many and varied forms today. Occupational education, career information or vocational guidance—whatever you choose to call it—is expanding at an accelerated rate. The Career Carnival is a good opportunity to "sell" the metalcastings industry. How about it? If your Chapter has participated in local educational programs, drop us a letter telling what you did.

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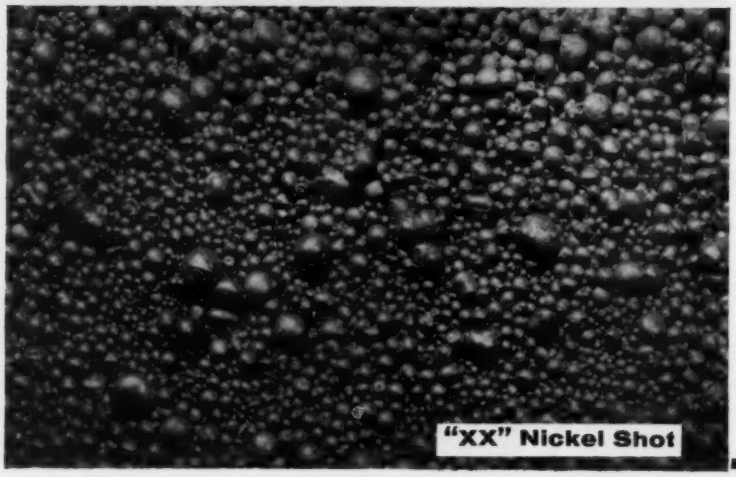
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Sizes available	Approx. size, in.	Packaging	Approx. wt., lbs.
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	(9x28½x⅜)		36
	(4½x28½x⅜)		18
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	(4x4x⅜)		2½
	(2x2x⅜)		–
	(1x1x⅜)		–
"QM" Quick Melting nickel squares	(1x1x⅛)	In steel drums 425 lb.	–



High-purity "XX"* Nickel Shot for alloying with iron and steel at spout or ladle. It is produced by pouring molten electrolytic nickel into a water bath. Standard sizing is obtained by screening through a one-inch opening and remaining on an .053-inch opening. Packed in 475 lb. drums.

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Nickel (including cobalt)	99.60%
Iron	.15
Silicon	.10
Carbon	.10

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Nickel (including cobalt)	92.00%
Silicon	5.50
Iron	1.65
Carbon	.55
Copper	.20

Nisiloy* Nickel-Silicon Inoculant for improving machinability in gray irons. The only inoculant improving *both* machinability and tensile strength. "Nisiloy" inoculant also improves uniformity and fineness of graphite distribution, wear resistance and toughness, while reducing chill and casting defects. Melts at 1800° F, diffuses rapidly. Supplied in granules sized ¾" to 20 mesh. Packed in 500 lb. drums.

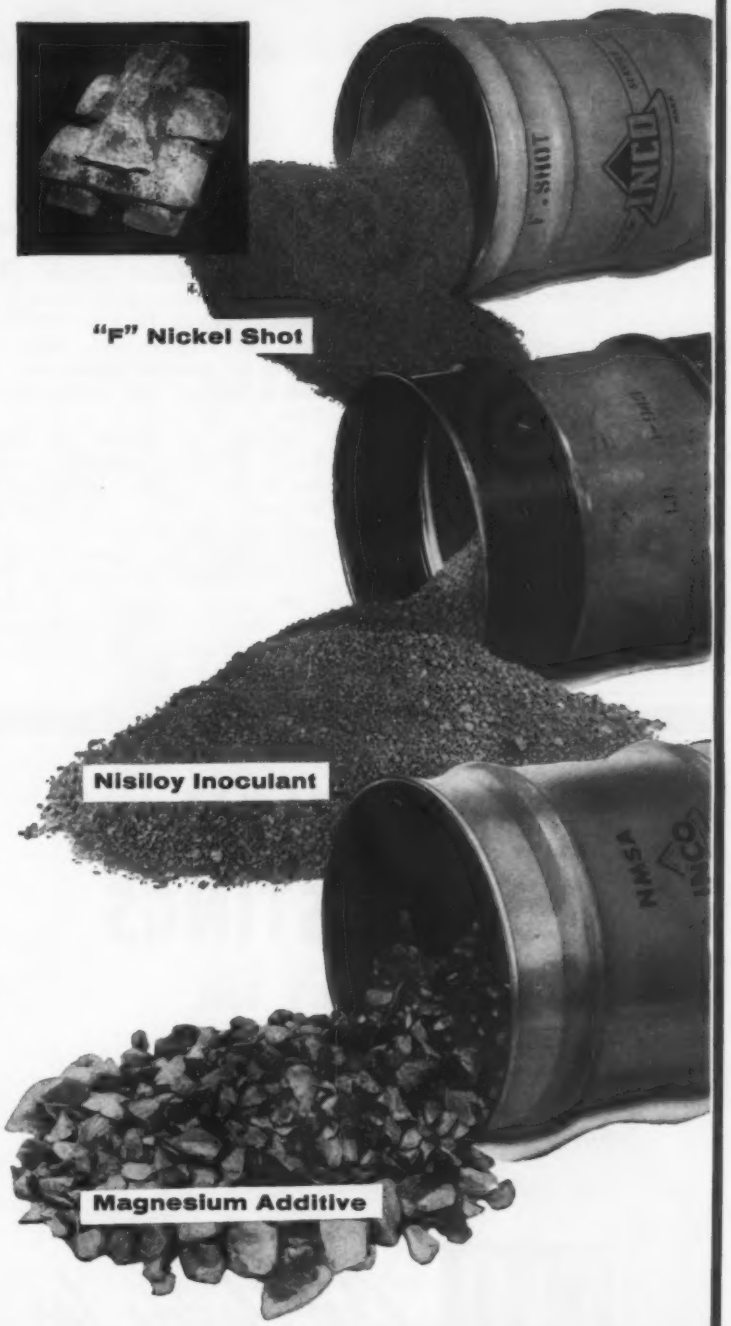
Nominal composition

Nickel	59.00%
Silicon	29.00
Iron	balance

Magnesium Additives – NMA #1* and NMSA #2* for obtaining desired properties in both regular and austenitic ductile irons. Useable with all types of melting units, with all methods of ductile iron production. Supplied in 2 sizes –2¼" x ¾" and 1" x 8" mesh.

NMA #1 Additive for high strength ductile iron. Provides most efficient magnesium recovery. Compared to other commercial additives, it has good response to heat treatment. Packed in 500 lb. drums. **Nominal composition:** 15% magnesium, balance Nickel.

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RADIATION SAFETY KNOW-HOW



by HERBERT J. WEBER

"Oh wad some Power the giftie gie us.....It wad frae monie a blunder free us" (ROBERT BURNS)

Julius Rosenwald, the financier, never accepted the popular notion that one who makes a lot of money has a lot of brains. One of his favorite stories follows. "A certain man won a million dollars on number 14. When asked how he did it, he said: 'I had a dream in which I saw number nine. The next night I saw number six in my dreams. So I put nine and six together and got 14.'"

Neither can I understand a prevalent notion that printing the truth about a radiation hazard will embarrass management or will deter foundrymen from using radioactive isotopes for casting inspection.

AFS recently published the FOUNDRY RADIATION PROTECTION MANUAL. A principal criticism received was that laymen should publish nothing about the physiological effects of radiation because they are not qualified and because such information would so frighten foundrymen that they would not use radioactive isotopes.

Actually the Chapter on "Physiological Effects of Radiation" was written by two qualified physicians and reviewed by three more. Thus it is not the work of laymen . . . and knowledge of the effects of radiation on man will not deter the use of isotopes anymore than the knowledge that silica dust can produce silicosis will cause foundrymen to stop making castings in sand.

Isotopes are so versatile that in some cases radiography is simpler with them than with x-ray machines; in other cases, isotopes can be used where x-ray equipment cannot. (There are still many jobs which can be done better by x-ray.)

The business end of an isotope unit is about the same size and shape as a pharmaceutical capsule. It emits radiation in all directions whereas an x-ray machine radiates in a unidirectional path.

The isotope "pill"—as it is called—can be inserted in a cylindrically-shaped casting and an entire circumferential radiograph may be obtained by a single exposure. Because the "pill" radiates in all directions, it can be used to radiograph many castings simultaneously by setting them up in a circle around the capsule.

By placing the radiation source in a valve body or in the water jacket of a tuyere, for example, radiographs can be obtained which would be impossible with x-ray equipment.

In one minute, with one exposure, 50 curies of iridium^{192} can radiograph the entire circumferential weld in a 40-in. diameter boiler with walls 3/4 in. thick.

These facts, together with the increasing trend towards even greater casting quality, are prompting foundrymen to turn to radiography not only for quality control but for satisfying customer requirements.

There is another widely believed misconception that radiation from radioactive materials can make other things radioactive. Some people mistakenly believe that one who works with radioactive materials will become radioactive. If a radiation source is left on a table and later removed, they believe the table is radioactive.

In one reported instance, a workman received an accidental overdose of radiation on his job and the incident was published in the newspapers. The neighbors in his community demanded that he and his family be quarantined lest they irradiate the whole neighborhood. I heard later that he had difficulty selling his "contaminated" house.

Admittedly radiation-producing equipment can be hazardous—so can automobiles, but they are very useful. But let's point out the hazards and safety precautions necessary and dispel misconceptions while at the same time taking advantage of these technological achievements.

And so AFS published the FOUNDRY RADIATION PROTECTION MANUAL —$6.00 to AFS members, $9.00 to non-members; but that adds up to 15, Bobbie Burns.

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Circle No. 206, Page 207

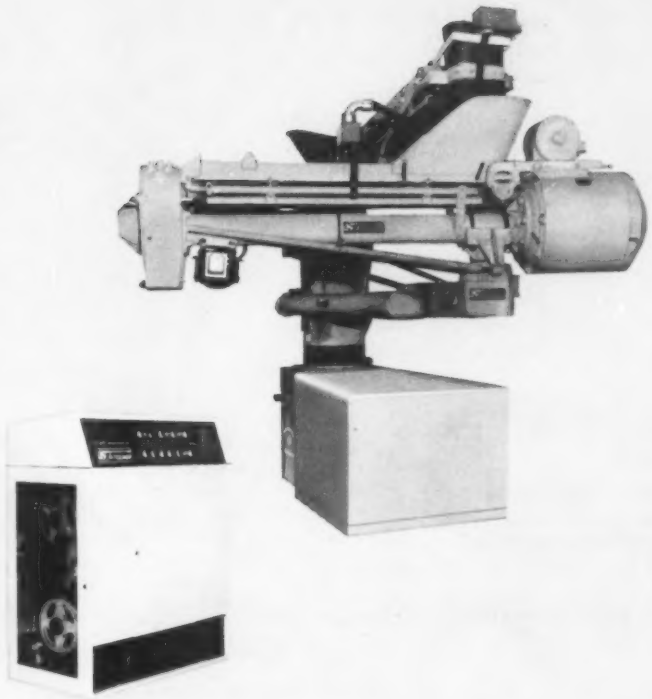
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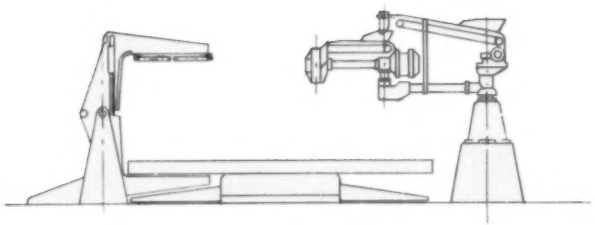
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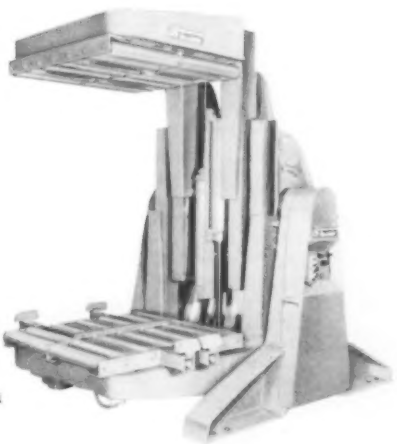
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- Costs less to install, less to maintain
- Rugged construction for rigidity and durability

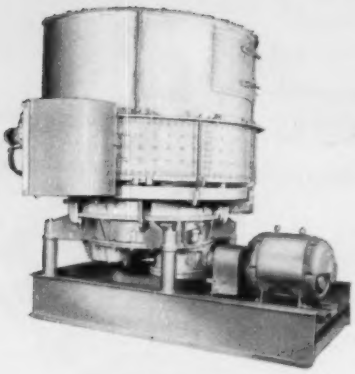
BEARDSLEY & PIPER Div. of Pettibone Mulliken Corp.
2424 N. Cicero Ave., Chicago 39, Ill.

MEMBER FEMA



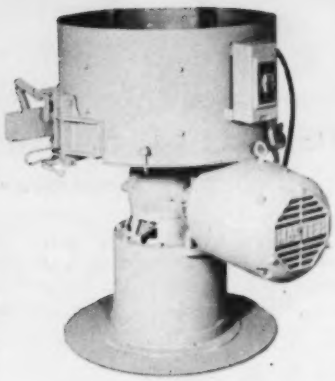
MULBARO

- The only really portable mullor
- Fast, thorough sand preparation
- Molding—core—shell—CO_2 or air-hardening sand
- Low initial cost . . . low operating cost
- No sand rehandling—several barrows can be used with one mulling unit



SPEEDMULLOR

- Lowest total cost per ton of prepared sand
- Minimum time cycles mean lower power costs
- Speedmullor cooling improves sand properties
- Optional Mulltrolmatic assures the ultimate in control and accuracy
- Compact Speedmullor-Preparator units for maximum sand conditioning capacity in minimum space



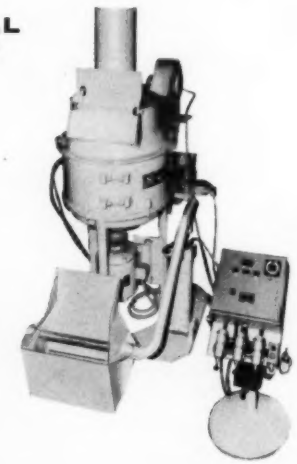
WHIRLMIX

- Fast, thorough blending of CO_2 (silicate of soda), air-setting, resin, core oil and other sand binders which do not require wheel mulling
- Compact and low cost—economical to operate
- Replaceable blades and arm shoes
- Easy discharge of sand—easy cleaning

B & P For The Broadest, Most Flexible Line of Coating Equipment For Shell Sand

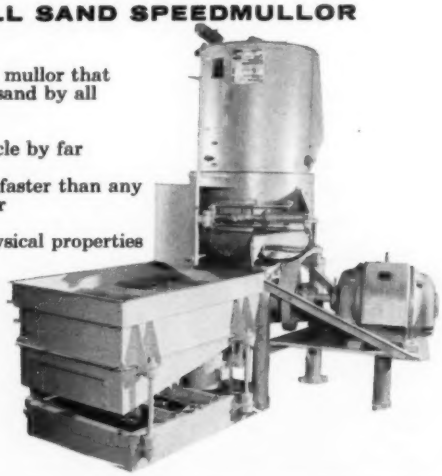
SHELL MULL-ALL PACKAGE UNIT

- Thoroughly coats shell sand at minimum cost
- Cold process or preheat process resin-coated shell sand
- Mulltrol automatic control assures batch after batch uniformity
- Greatest capacity in its field
- A complete, ready to operate package . . . easily installed . . . no pits



HP SHELL SAND SPEEDMULLOR

- The ONLY mullor that resin-coats sand by all processes
- Shortest cycle by far
- Four times faster than any other mullor
- Highest physical properties
- Most capacity per dollar invested



B & P FOR THE MOST COMPLETE LINE OF FOUNDRY EQUIPMENT—
AUTOSLINGER ● SANDSLINGER ● SPEEDSLINGER ● HYDRA-SLINGER ● SPEEDMULLOR ● PREPARATOR ● SPEEDMULLOR-PREPARATOR UNIT ● SHELL SPEEDMULLOR ● MULL-ALL ● MULBARO ● LAB MULBARO ● PNEU-RECLAIM ● FORMATIC SHELL MOLD UNIT ●

see highlights of the latest B & P research

From B & P RESEARCH hollow shell cores and molds of unmatched accuracy

A Complete Line Of The World's Fastest Selling Coreblowers

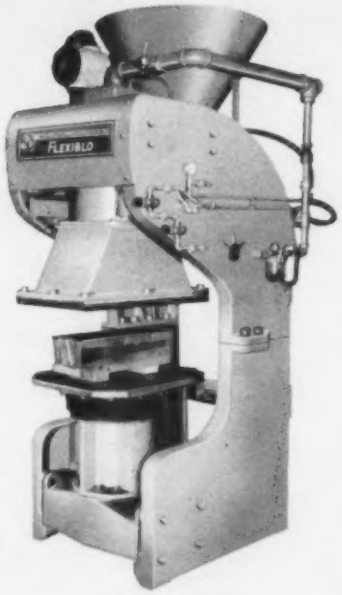
core handling equipment for every need

B & P NCR ROL-A-COR

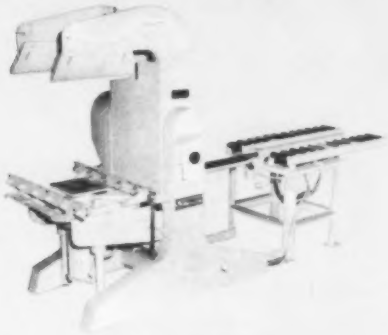
For Jobbing And Semi-Production Requirements

FLEXIBLO

- From a few ounces to 400 pounds capacity
- Extra large combination blow and exhaust valve
- Simple pneumatic automatic sequence control
- Proved safest—minimum maintenance
- Fast, smooth, vertical clamping with combination piston-diaphragm design
- Handles any core box—wood or metal
- Blows all types of core sands
- Balanced, versatile design for production or jobbing work
- Choice of semi-automatic or fully automatic operation



CB15 FLEXIBLO



- Cuts core room handling costs
- Fast handling—accurate draws with either automatic or semi-automatic push button control
- Fast, 7 to 10 second complete rollover cycle
- Handles a wide range of core boxes
- Maximum flexibility—roll-in and roll-out conveyors can be mounted for 90° or straight away core box travel

For production requirements—precise rapid draws with B & P TR Rol-A-Cor.

FLEXIGAS FOR THE CO_2 PROCESS

- New package unit for maximum efficiency
- 2 FG 5-10 gassing units and one CB5 provide a balanced operation
- Fast, low cost production of CO_2 cores
- Adjustable gassing time from 0 to 30 seconds
- Handles any core box varying up to 4" in height without machine adjustments
- Flexigas units have single push-button operation—automatic sequence control
- FG 5-10 Flexigas available in package unit or separately
- FG 12-20 available for larger work—choice of 2 types of automatic horizontal clamps for gassing vertically parted core boxes



PNEU-RECLAIM

Sand Reclamation You Can Afford

- Lowest installation cost
- Easy maintenance
- Lower operating cost because of low power requirements
- Exact fines-control built in



CORMATIC SHELL CORE UNIT ● FLEXIBLO ● SAN-BLO ● WHIRLMIX ● ROL-A-DRAW ● ROTO-MOLD ● ROTO-FEED ● HYDRA-MOLD ● BEEP ● SKIPTROL ● MULLTROL ● MULLTROLMATIC ● BLOMATIC ● CORMATIC ● NITE GANG ● MAGNARATOR ● FOUNDRY-MITES

developments at the AFS Foundry Show



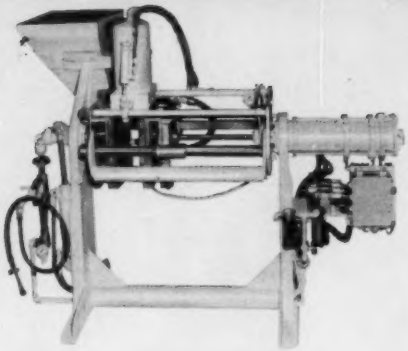
dietrich's corner

by h. f. dietrich



MEASURE TEMPERATURES

From B & P **RESEARCH** hollow shell cores and molds of unmatched accuracy

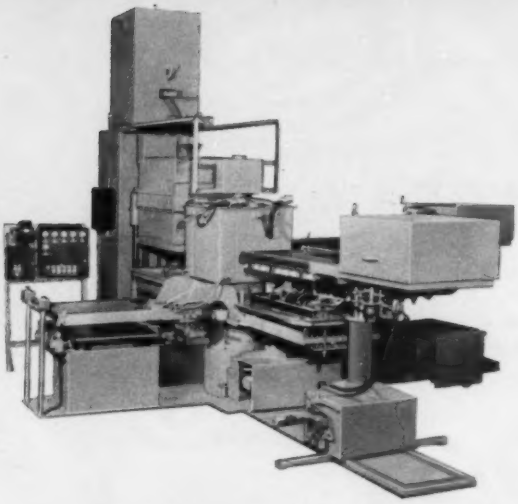


SF-6A CORMATIC

Makes Better Hollow Shell Cores Faster And At Less Cost

- Completely automatic—single push of button actuates entire cycle
- Largest core box capacity of any machine in its class
- Highest BTU output—greater than similar machines by as much as two to one—assures faster curing
- One man operates three SF-6A Cormatics—strips up to 240 boxes per hour

The SF-6 Cormatic...The low Cost, Easy To Operate Hollow Shell Core Unit identical to the automatic Cormatic in core box capacity with the same high heat output and temperature control.



FORMATIC SHELL MOLD MACHINE

- Maximum productivity with minimum floor space
- Maximum flexibility for every production requirement
- One, two, three or four pattern units
- Automatic operation—every essential factor is precisely controlled
- Enlarge as required—package design

THE FOUNDRY MITES



SCREENARATORS



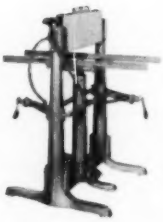
WIRE CUTTERS



WIRE STRAIGHTENERS



JOLT SQUEEZE MACHINES



VIBRA-DRAWS



ELECTRIC RIDDLES

A Line Of Flexible Machinery That Is Ideal For Small Jobs In Large Foundries And Large Jobs In Small Foundries

Performs 1001 Foundry Jobs Efficiently—Economically

see B & P's money savers at the AFS Foundry Show



dietrich's corner

by h. f. dietrich



THE DOLLAR-AN-HOUR MAN

"I would work harder IF I got more money."

■ How many of you have heard this statement so often that you are almost convinced it is true? Even the government insists that a man's time is worth at least a dollar an hour. But the proposition that a day worker will work harder if you pay him more money is a myth, a fairy tale, a deliberate misstatement of fact designed to cover a feeling of inferiority. Or it's a shrewd challenge to catch the loafer at his own game—if you can.

My first experience with the dollar-an-hour man was the shakeout crew of a small foundry. I was a brand new foreman with ideas of my own about how men should be handled to get the best production from them. Naively believing that all men were inherently honest, I would assign the job, show the man how it should be done, and then leave him to complete it. In most cases, the men justified my confidence in them. Then, I hired one of these professional work-dodgers. There were a lot of things about dogging on a job that I didn't know, but this expert taught me most of them before he bowed out.

First I learned that the apparent effort put into the work as I walked by to see how things were progressing had no bearing on the amount of work produced. Men are creatures of habit. I made the rounds of the foundry at regular intervals, but each time my featherbedding friend was further behind in his work. I knew that the effort I saw should have produced better results but it was impossible to catch this past master of the art of slowdown in any irregularity.

Trying to catch him became a sort of game. It was a challenge. I changed the time of my rounds of the shop. This produced no results. I changed the direction of my route. I might as well have stayed in the office. This expert had been caught on all of these dodges before. He knew instinctively where I was going to be before I did.

After retiring to the office to give the situation some constructive thought, I came to a profound conclusion. The philosophy of the professional, workshirking, dollar-an-hour artist is based on doing a daywork job at such a pace that perspiration is never a problem. To live up to this credo while working with a shakeout crew on a squeezer floor is almost impossible, but the true artist will certainly give it a try.

By leaving the office by the front door and coming back into the foundry by way of the darkened core-room, I finally caught my pipe smoking friend stretched out comfortably on some bottomboards. Being new at foremanship, my next move was a tactical error. It is practically impossible to get a replacement shakeout man at four o'clock in the morning. So I had to take over the job myself. This was the first man I had ever discharged for cause. But as the night turned to dawn I found myself wishing that I could rehire him so that I could fire him again. To this day I still remember his name and the sore muscles he put in my back.

The other type of dollar-an-hour man is slow unintentionally. His original transmission has only two gears, and there is nothing you can say, or do, that will change his speed. He has excellent prospects for a long life because he refuses to burn himself out in the hypertension of our modern industrial jungle. He is dependable and would serve well in some position where a piece of ornamental statuary is requried.

In either of these cases, payment of more money wouldn't improve production. Therefore, the statement that, *"I would work harder IF I got more money,"* is a myth.

MEASURE TEMPERATURES ACCURATELY FAST with

the improved

PYRO OPTICAL PYROMETER



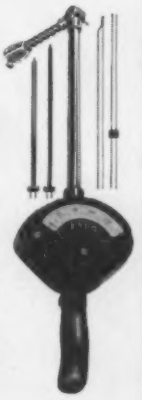
The only self-contained direct-reading optical pyrometer for quick temperature readings of molten iron, steel, monel, etc.

Send for FREE catalog No. 85.

and

the NEW!

PYRO IMMERSION PYROMETER



Quickly gives precise temperatures of molten non-ferrous metals. Thermocouples interchanged instantly. Ranges from 1000° to 2500°F.

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PYROMETER INSTRUMENT CO., INC.

BERGENFIELD 10, NEW JERSEY

Circle No. 145, Page 207

Circle No. 206, Page 207



Circle No. 146, Page 207

NEW *NESTING PIG* FROM KAISER ALUMINUM RIDES OUT ROUGHEST TRANSIT...ARRIVES INTACT

Now, when you order pig from Kaiser Aluminum, you can be doubly sure each bundle will arrive as it was shipped—in first-class condition.

Planned Right—Engineered to Nest

Kaiser's engineers have developed a new pyramidal *nesting* shape which permits stabilized stacking into tight, square bundles that stay put. With this new arrangement, pigs are nested alternately face up and face down in a row. And every row is placed at right angles to every other.

Proved Right—Laboratory Tested

Independent laboratory tests prove that even beyond maximum normal shock or jarring conditions, new Kaiser Aluminum nesting pig can't twist, flip or reverse position within the bundle.

Packaged Right—Polyethelene Protected

Shipped in packages of 44 standard 50 lb. pigs, each bundle is secured length and width by two 1¼" high tensile steel bands, tightly set in specially designed slots. Pigs can't loosen until these bands are cut. Even then stacks remain intact.

Each bundle is wrapped in polyethylene bags for optimum cleanliness in transit and storage.

For complete information on availabilities of this new nesting pig, contact the Kaiser Aluminum representative or distributor near you. Or write: Kaiser Aluminum & Chemical Sales, Inc., Kaiser Center, Oakland 12, California



Torture-tested under unusually severe vibration and impact conditions by Gaynes Engineering Company, Chicago, new Kaiser Aluminum nesting pig came through every time completely intact, just as bundled.

See "MAVERICK" • Sunday Evenings, ABC-TV Network • See local TV listing.

KAISER ALUMINUM*

*TRADEMARK KAISER ALUMINUM & CHEMICAL CORPORATION

Circle No. 146, Page 207

coke...literally hand-picked...
to give you better melting in your cupola



Every foundryman knows how important *uniform coke size* is to a successful melting operation. Size bears a close relationship to carbon absorption, temperature rise, rate of combustion or reactivity, and to pressures.

That's why Semet-Solvay screens its five standard sizes of coke so carefully. And *after* screening, it is actually *hand-picked* to eliminate any oversized or off-quality pieces which might affect results in your cupola.

Yes, there's a size of Semet-Solvay coke just right for your foundry—it's uniform in size and quality for uniform results.

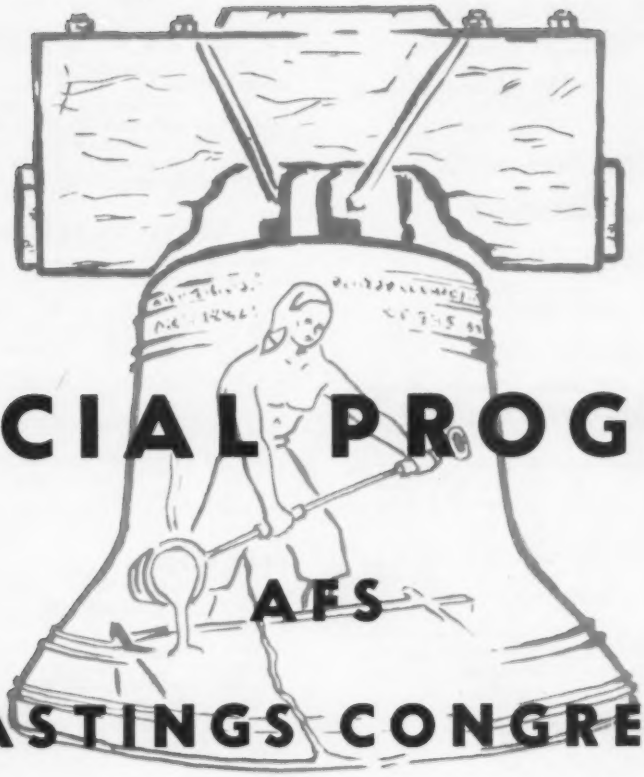
For the whole story, write today for our brand-new booklet, "The Advantages of Using Semet-Solvay Foundry Coke."

Allied Chemical

SEMET-SOLVAY DIVISION

Dept. 572-BI, 40 Rector Street, New York 6, N. Y.

Circle No. 147, Page 207



OFFICIAL PROGRAM

AFS

CASTINGS CONGRESS

This Official Program has been prepared by MODERN CASTINGS *to help you efficiently use every minute of your valuable time when attending the 64th AFS Castings Congress & Exposition in Philadelphia, May 9-13. Convention Hall will be the focal point for most of the big events . . . the Exposition—100,000 square foot showplace for 209 of the most progressive manufacturers serving the metalcastings industry . . . the Castings Congress—more than 100 carefully selected technical papers, written and presented by over 250 foundry authorities . . . Special Events—luncheons, dinners, awards, shop courses and local foundry tours. All this and more is previewed in the count-down of big events covered in the following pages.*

Monday, May 9

7:30 AM
AUTHORS–CHAIRMEN BREAKFAST
Pennsylvania East Room, Sheraton Hotel

8:30 AM
REGISTRATION OPENS (to 5:30 pm)
Main Lobby, Convention Hall

9:00 AM
EXHIBITS OPEN (to 5:30 pm daily, except 5:00 pm Fri.)

9:00 AM
LADIES' REGISTRATION OPENS (to 3:00 pm)
Pink Room, Bellevue Stratford Hotel

9:30 AM
BRASS AND BRONZE SESSION

Room B, Convention Hall

Presiding–J. E. Gotheridge, Foundry Services, Inc., Cleveland. A. L. Proctor, Bethlehem Steel Co., Bethlehem, Pa.

Formation of Dispersions in Molten Copper by Mechanical Mixing–D. N. Williams, J. W. Roberts, R. I. Jaffee, Battelle Memorial Institute, Columbus, Ohio.

Fluidity of 85-5-5-5 and Composition "M" Metal–R. A. Rosenberg, H. D. Brody, F. C. Monkman, Jr., Walworth Co., South Braintree, Mass.

Brass and Bronze Research Progress Report–sponsored by AFS Training and Research Institute–R. A. Flinn, Universtiy of Michigan, Ann Arbor.

LIGHT METALS SESSION

Room A, Convention Hall

Presiding–R. W. Huber, U. S. Naval Research Laboratory, Washington, D. C.
J. G. Kura, Battelle Memorial Institute, Columbus, Ohio.

Inclusion Identification in Magnesium Alloy Castings–B. Lagowski, W. A. Pollard, Department of Mines and Technical Surveys, Ottawa, Ont., Can.

Casting of Ordnance Type Titanium Parts–H. McCurdy, Battelle Memorial Institute, Columbus, Ohio and H. Antes, R. E. Edelman, Frankfort Arsenal, Philadelphia.

Factors Contributing to the Soundness of Titanium Castings–J. W. Smith, T. A. Hamm, Oregon Metallurgical Corp., Albany, Ore.

MALLEABLE SESSION

Room 200, Convention Hall

Presiding–C. R. Sorensen, National Malleable & Steel Castings Co., Cicero, Ill.

E. A. Oldfield, Chicago Malleable Castings Co., Chicago.

Growth of White Iron During Malleablizing– N. R. Kelley, B. A. Ruediger, General Electric Co., Shelbyville, Ind.

Hardenability of Mn-Mo Alloyed Pearlitic Malleable Iron–Progress Report on Malleable Iron Research, sponsored by AFS Training & Research Institute–R. W. Heine, University of Wisconsin, Madison, Wis.

PATTERN SESSION

Room 101, Convention Hall

Presiding–J. M. Kreiner, National Malleable & Steel Castings Co., Cleveland. R. L. Olson, Dike-O-Seal, Inc., Chicago.

Carbonyl Deposition of Nickel for Patternmaking–J. O. Trimble, Carbonyl Products Div., The Budd Co., Philadelphia.

Electroforming for Pattern Construction & Repair–P. J. Ritzenthaler, Plating Engineering Corp., Milwaukee.

12:00 NOON
MALLEABLE ROUND TABLE LUNCHEON

Room 300, Convention Hall

Presiding–E. Welander, John Deere Malleable Works, East Moline, Ill. B. C. Yearley, National Malleable & Steel Castings Co., Cleveland. D. L. LaMarche, Jr., American Malleable Castings Co., Marion, Ohio.

Subject–Are We Measuring Up?

Speaker–Hans J. Heine, Malleable Founders' Society, Cleveland.

2:00 PM
BRASS AND BRONZE SESSION

Room B, Convention Hall

Presiding–J. D. Allen, Jr., Federated Metals Div., American Smelting & Refining Co., Newark, N. J. R. C. Stokes, Crown Non-Ferrous Foundry, Inc., Chester, Pa.

The Effect of Section Thickness, Gas Content and Directional Solidification on Mechanical Properties of Eight Copper-Base Casting Alloys–J. O. Edwards, D. A. Wittaker, Department of Mines and Technical Surveys, Ottawa, Ont., Canada.


F. C. Monkman


D. N. Williams


H. D. Brody


R. A. Rosenberg


B. Lagowski


N. R. Kelley

The Inherent Characteristics of Cast 70/30 Cupro-Nickel—B. F. Shepherd, Ingersoll-Rand Co., Phillipsburg, N. J.

PATTERN SESSION

Room 101, Convention Hall

Presiding— W. E. Mason, Westinghouse Air Brake Co., Wilmerding, Pa.
H. W. Mess, John Deere Planter Works, Moline, Ill.

New Materials for Wood Patternmaking—R. LeMaster, Nelson Pattern Co., Milwaukee.

The Shaw Process for Patternmaking—I. Lubalin, Shaw Process Development Corp., Port Washington, N. Y., R. J. Christensen, Wisconsin Pattern Works, Inc., Racine, Wis.

4:00 PM

BRASS AND BRONZE SEMINAR

Room B, Convention Hall

Presiding—F. L. Riddell, H. Kramer & Co., Chicago.
C. E. Muller, Ingersoll-Rand Co., Phillipsburg, N. J.

Subject—Salvage and Repair of Copper-Base Alloy Castings.
Impregnation—C. Behen, Metallizing Co. of America, Chicago.

Weld Repair of Aluminum and Manganese Bronzes—E. Garriott, Ampco Metal, Inc., Milwaukee.

Weld Repair of Tin Bronzes—J. Mikulak, Worthington Corp., Harrison, N. J.

SAND SESSION

Ballroom, Convention Hall

Presiding—R. H. Olmsted, Whitehead Bros., New York. C. A. Robeck, Gibson & Kirk Co., Baltimore, Md.

Parashrinkage Phenomena—Veining, Metal Penetration, Scabbing, Hot Tearing—D. C. Williams, Ohio State University, Columbus, Ohio.

Study of Surface Area Measurements & Theoretical & Experimental Relation to Angularity & Shape Factors in Foundry Sands—G. J. Vingas, A. H. Zrimsek, Magnet Cove Barium Corp., Arlington, Heights, Ill.

Canadian Non-Ferrous and Iron Foundry Sand Practice Survey—Report Committee 8-Y—A. E. Murton, Department of Mines and Technical Surveys, Ottawa, Ont., Can.

8:00 PM

SAND SHOP COURSE

Pennnsylvania Center Room, Sheraton Hotel

Presiding—L. E. Wile, Lynchburg Foundry Co., Lynchburg, Va. T. W. Seaton, American Silica Sand Co., Ottawa, Ill.

Panel—New Horizons in Sand Practice.

Green Sand—C. M. Eberhardt, Central Foundry Div., G.M.C., Danville, Ill.

Air Setting Binders—D. N. Rosenblatt, American Foundry & Machine Co., Salt Lake City.

Shell Molds—W. C. Capehart, Monsanto Chemical Co., Springfield, Mass.

8:00 PM

MALLEABLE SHOP COURSE

Hall of Flags, Sheraton Hotel

Presiding—J. W. Beckham, Texas Foundries, Inc., Lufkin, Texas. R. J. Franck, Superior Steel & Malleable Castings Co., Benton Harbor, Mich.

Panel:
Demonstration Showing Various Elements Accounting for Casting Failure—C. R. Baker, Albion Malleable Iron Co., Albion, Mich.

Demonstration Showing Casting Replacing Poorly Designed Stamping—J. L. Flitz, Central Foundry Div., G.M.C., Saginaw, Mich.

Need for Direct Communication between Foundrymen and Designer—H. J. Heine, Malleable Founders' Society, Cleveland.

Discussion of Design Engineers' Terms—J. B. Caine, Cincinnati.

How Lacquer Coatings are used for Stress Analysis—R. A. Johns, Belle City Malleable Iron Co., Racine, Wis.

Scrap Reduction through Better Design—J. W. Beckham, Texas Foundries, Inc., Lufkin, Texas.

Motion Picture Film—*The Big Difference.*

Summation of the Shop Course—R. J. Franck, Superior Steel & Malleable Castings Co., Benton Harbor, Mich.


D. C. Williams


G. J. Vingas


R. LeMaster


A. E. Murton


B. A. Ruediger


H. J. Heine

Tuesday, May 10

7:30 AM
AUTHORS–CHAIRMEN BREAKFAST

Pennsylvania East Room, Sheraton Hotel

8:30 AM
REGISTRATION OPENS (to 5:30 pm)

9:00 AM
EXHIBITS OPEN

LADIES REGISTRATION OPENS (to 3:00 pm)

9:30 AM
BRASS AND BRONZE SESSION

Room B, Convention Hall

Presiding–A. W. Bardeen, Ohio Brass Co., Mansfield, Ohio.
R. F. Schmidt, Ajax Metal Div., H. Kramer & Co., Philadelphia.

Shell Molded Test Bars for Tin Bronze Casting Alloys–S. Goldspiel, E. W. Chrzan, M. L. Foster, New York Naval Shipyard, Brooklyn, N. Y.

A New Method for Degassing Copper Base Foundry Alloys–R. J. Cooksey, R. W. Ruddle, Foundry Services, Inc.

Casting Characteristics of a Mn-Ni-Al Bronze for Propellers–G. H. Bradshaw, M. M. Kennedy, S. H. Dorn, Philadelphia Naval Shipyard, Philadelphia.

MALLEABLE SESSION

Room 200, Convention Hall

Presiding–C. F. Joseph, Central Foundry Div., G.M.C., Saginaw, Mich. G. F. Sommer, Link-O-Belt Co., Indianapolis.

Effect of Addition to the Melt on Mottling Tendency in Heavy Sections–Second Progress Report (Part I) on Investigation of Casting Heavy-Section Malleable Iron, sponsored by AFS Training & Research Institute–C. R. Loper, Jr., R. W. Heine, University of Wisconsin, Madison, Wis.

Effects of Additions to the Melt on Annealability of White Iron–Second Progress Report (Part II) on an Investigation of Casting Heavy-Section Malleable Iron, sponsored by AFS Training & Research Institute–C. R. Loper, Jr., R. W. Heine, J. Waring, University of Wisconsin, Madison, Wis.

PATTERN SESSION

Room 101, Convention Hall

Presiding–M. K. Young, U. S. Gypsum Co., Chicago.

N. C. Jones, New York Air Brake Co., Watertown, N. Y.

Pattern and Core Box Equipment for Blowing Foundry Sands, Venting and Design–Z. Madacey, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago.

Plastic Patterns New Tools and Equipment–F. Kobee, Ohio Metal Fibers, Toledo, Ohio.

SAFETY, HYGIENE AND AIR POLLUTION CONTROL SESSION

Room A, Convention Hall

Presiding–K. M. Smith, Caterpillar Tractor Co., Peoria, Ill.
R. L. McIlvaine, National Engineering Co., Chicago.

Dust Collector Review–D. G. Stephan, U. S. Department of Health, Education and Welfare, Cincinnati.

Loss Prevention Through Accident Prevention in the Foundry–G. A. Riley, American Brake Shoe Co., New York.

Motion Picture–*Its Up To You.*

An Eye for an Eye–J. E. O'Neil, National Society for the Prevention of Blindness, New York.

Motion Picture–*Low Volume, High Velocity Exhaust Systems.*

AFS INSTITUTE TRUSTEES

12:00 NOON
AFS BOARD OF DIRECTORS LUNCHEON AND BUSINESS MEETING

Connie Mack Room, Sheraton Hotel

BRASS AND BRONZE ROUND TABLE LUNCHEON

Auditorium, Convention Hall

Presiding–E. F. Tibbetts, Wollaston Brass & Aluminum Foundry, Inc., Quincy, Mass.
R. R. Ashley, Detroit Controls Div., American Standards Co., Monroe, Conn.

Subject–What's Ahead for the Copper-Base Alloy Foundry Industry.

Speaker–N. A. Birch, National Bearing Div., American Brake Shoe Co., St. Louis.

PATTERN ROUND TABLE LUNCHEON

Room 300, Convention Hall


S. Goldspiel


E. W. Chrzan


M. L. Foster


A. De Sy


Z. Madacey


D. G. Stephan

Presiding—J. M. Kreiner, National Malleable & Steel Castings Co., Cleveland.
R. L. Olson, Dike-O-Seal, Inc., Chicago.

Subject—Marketing Your Product.

Speaker—S. C. Massari, American Foundrymen's Society, Des Plaines, Ill.

2:00 PM

EDUCATION SESSION

Room B, Convention Hall

Presiding—J. Toth, Harry W. Dietert Co., Detroit.
J. L. Leach, University of Illinois, Urbana.

An Evaluation of Various Methods of Fabrication—J. G. Frantzreb, Caterpillar Tractor Co., Peoria, Ill.

GRAY IRON SESSION

Room 200, Convention Hall

Presiding—C. F. Walton, Gray Iron Founders' Society, Cleveland. H. E. Henderson, Lynchburg Foundry Co., Lynchburg, Va.

Microstructural Changes upon Tempering of Nickel Chromium White Iron at 400 F—J. R. Mihalisin, R. D. Schelleng, International Nickel Co., Bayonne, N. J.

Gray Cast Iron Charpy Impact Test and Impact Modulus—A. De Sy, University of Ghent, Ghent, Belgium.

INDUSTRIAL ENGINEERING & COST SESSION

Room 101, Convention Hall

Presiding—W. E. Boswell, Glamorgan Pipe & Foundry Co., Lynchburg, Va. E. C. Reid, Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.

Controlling Costs of Foundry Operations—K. T. Rinderle, Farrell-Cheek Steel Co., Sandusky, Ohio.

Job Evaluation—Asset or Liability—A. G. McNichol, Canada Iron Foundries, Ltd., Toronto, Ont., Canada.

STEEL SESSION

Ballroom, Convention Hall

Presiding—W. M. Spear, Worthington Corp., Harrison, N. J. I. B. Elman, International Nickel Co., Bayonne, N. J.

Oxygen-Gas Burner Use for Scrap Meltdown in the Small Arc Furnace—V. J. Howard, Oklahoma Steel Castings Co., Tulsa, Okla.

Alloy 20 Stainless Steel Production & Mechanical Properties—L. Fink, Electric Steel Foundry Co., Portland, Ore.

LIGHT METALS SESSION

Room A, Convention Hall

Presiding—D. L. LaVelle, American Smelting & Refining Co., S. Plainfield, N. J.
J. W. Meier, Department of Mines & Technical Surveys, Ottawa, Ont., Canada.

Short Time Elevated Temperature Properties of Premium Quality Magnesium Castings—W. Gronvold, Boeing Airplane Co., Seattle.

Thermal Requirements for Porosity-Free Magnesium Alloy Castings—R. D. Green, The Dow Chemical Co., Midland, Mich.

Techniques for Producing Premium Quality Magnesium Castings for Missile Applications—M. C. Flemings, E. J. Poirier, H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

4:00 PM

GRAY IRON SESSION

Room 200, Convention Hall

Presiding—J. Varga, Jr., Battelle Memorial Institute, Columbus, Ohio.
K. Presser, Buckeye Foundry Co., Cincinnati.

Feeding Distance of Risers for Gray Iron Castings—Progress Report on Gray Iron Research, sponsored by AFS Training & Research Institute—G. K. Turnbull, H. D. Merchant, J. F. Wallace, Case Institute of Technology, Cleveland.

Operating Experience with a Lining-less, Water Cooled Cupola—M. E. Rollman, D. J. Pusack, Cincinnati Milling Machine Co., Cincinnati.

LIGHT METALS SESSION

Room A, Convention Hall

Presiding—W. E. Sicha, Aluminum Co. of America, Cleveland.
J. G. Mezoff, The Dow Metal Products Co., Div. The Dow Chemical Co., Midland, Mich.

Effect of Casting Temperature on Aluminum Alloy Test Bar Properties—J. W. Meier, A. Couture, Department of Mines and Technical Surveys, Ottawa, Ont., Canada.

Approach to Rigging Aluminum—7% Magnesium Castings—J. G. Kura, W. A. Johnson, Battelle Memorial Institute, Columbus, Ohio.

Developments in Magnesium Practice—J. G. House. The Dow Chemical Co., Bay City, Mich.



K. T. Rinderle



A. G. McNichol



W. Gronvold



Y. A. Nekhendzi



N. A. Birch



S. C. Massari

Tuesday, May 10

MALLEABLE SESSION

Room 300, Convention Hall

Presiding—O. K. Hunsaker, Dayton Malleable Iron Co., Dayton, Ohio. W. L. Olsen Jr., Wagner Castings Co., Decatur, Ill.

Panel—Malleable Straightening Dies

Hot Straightening of Transmission Ring, Transmission Part, Pipe Coupling—R. E. Elsea, Saginaw Malleable Iron Plant, G.M.C., Saginaw, Mich.
Hay Conditioner, Case Die, Twine Needle—L. E. Sutton, John Deere Malleable Iron Works, East Moline, Ill.
Transmission Fork, Bearing Cap, Crankshaft—W. L. Olsen, Jr., Wagner Castings Co., Decatur, Ill.
Differential Case Die, Carrier Die, Spring Hanger, N. Zitta, Auto Specialties Mfg. Co., St. Joseph, Mich.
300 pound Side Cover, Chrysler Torsion Bar O. K. Hunsaker, Dayton Malleable Iron Co., Dayton, Ohio.

SAND SESSION

Ballroom, Convention Hall

Presiding—W. R. Moggridge, Canada Iron Foundries, Ltd., Toronto, Ont., Canada.
E. C. Troy, Pennsylvania Electric Steel Castings Co., Hamburg, Pa.

Apparent Thermal Conductivity of Molding Sand at Elevated Temperatures—D. H. Whitmore, Q. F. Ingerson, Northwestern University, Evanston, Ill.

Molding Sand Control by Green Compressive & Green Shear Strengths Testing-R. W. Heine, University of Wisconsin, Madison, and J. S. Schumacher, E. H. King, Hill & Griffth Co., Cincinnati.

Sampling of Sand, Grading, Fineness & Distribution Committee 8-F Report, Sand Division.

7:00 PM

CANADIAN DINNER

Pennsylvania Ballroom, Sheraton Hotel

Presiding—A. J. Moore, Canadian Bronze Co., Ltd., Montreal, Quebec, Canada.

SAND DINNER

Crystal Ballroom, Benjamin Franklin Hotel

Presiding—V. M. Rowell, Federal Foundry Div., Archer-Daniels-Midland Co., Cleveland.

Speaker—Ylian A. Nekhendzi, Head of Chair of Foundry Production, Leningrad Polytechnic Institute, Leningrad, U.S.S.R.

Subject—Foundry Production in the U.S.S.R.

8:00 PM

GRAY IRON SHOP COURSE

Pennsylvania Center Room, Sheraton Hotel

Presiding—H. H .Wilder, Vanadium Corp. of America, Chicago. W. W. Holden, Dostal Foundry & Machine Co., Pontiac, Mich. E. J. Burke, Hanna Furnace Corp., Buffalo, N. Y.

Subject—Fundemental Behavior of Gray Iron: Iron, Carbon, Silicon—their Behavior, Mode of Solidification, Influence on Fluidity.

MALLEABLE SHOP COURSE

Hall of Flags, Sheraton Hotel

Presiding—W. C. Truckenmiller, Albion Malleable Iron Co., Albion, Mich.

Panel—Melting Materials and Procedures

Silvery Pig Iron vs. Ferro Silicon and Ferro Manganese vs. Spiegel—H. T. Sheppard, Belle City Malleable Iron Co., Racine, Wis.; *Typical Cold Charge and Charge Cost*—J. W. Clarke, General Electric Co., Erie, Pa.; *Malleable Pig vs. Steel Scrap*—C. M. Eberhardt, Central Foundry Div., G.M.C., Danville, Ill.; *Hot Blast vs. Cold Blast*—N. Lillybeck, Modern Equipment Co., Port Washington, Wis.; *Northern vs. Southern Coke*, W. E. Jaeschke, Whiting Corp., Harvey, Ill.

Wednesday, May 11

7:30 AM

AUTHORS—CHAIRMEN BREAKFAST

Pennsylvania East Room, Sheraton Hotel

8:30 AM

REGISTRATION OPENS (to 5:30 pm)

9:00 AM

LADIES' REGISTRATION OPENS (to 3:00 pm)

9:30 AM

AFS ANNUAL BUSINESS MEETING

Ballroom, Convention Hall

Presiding—AFS President Charles E. Nelson.


V. J. Howard


J. Zotos


M. E. Rollman


J. W. Meier


J. G. House


F. R. Kobee

President's Annual Address.
Election of Officers and Directors.
Apprentice Contest Awards.
Presentation of AFS Awards of Scientific Merit.
Presentation of AFS Service Citations.

10:30 AM

CHARLES EDGAR HOYT MEMORIAL LECTURE

Ballroom, Convention Hall

Subject—Where Do We Go From Here?

Lecturer—W. J. Grede, President, J. I. Case Co., Racine, Wis.

11:00 AM

EXHIBITS OPEN

12:00 NOON

MANAGEMENT DEVELOPMENT LUNCHEON AND SESSION

Room 300, Convention Hall

Presiding—L. H. Durdin, Dixie Bronze Co., Birmingham, Ala.

Speaker—Richard MacNabb, Machinery and Allied Products Institute, Washington, D.C.

Subject—Realistic Depreciation for Foundry Equipment.

JOINT LIGHT METALS AND DIE CASTING ROUND TABLE LUNCHEON

Auditorium, Convention Hall

Presiding—F. C. Bennett, The Dow Metal Products Co., Div., The Dow Chemical Co., Midland, Mich.
J. G. Mezoff, The Dow Metal Products Co., Div., The Dow Chemical Co., Midland, Mich.

Subject—The Aluminum Engine.

Panel—B. J. Mitchell, General Motors Corp., Technical Center, Detroit, *The Designer Looks at the Aluminum Engine.*

J. Smith, Aluminum Co. of America, Cleveland, *The Foundrymen Looks at the Aluminum Engine.*

FOUNDRY EDUCATIONAL FOUNDATION TRUSTEES LUNCHEON

Green Room, Warwick Hotel

2:00 PM

FOUNDRY EDUCATIONAL FOUNDATION TRUSTEES MEETING

Locust Room, Warwick Hotel

GRAY IRON SESSION

Room 200, Convention Hall

Presiding—H. W. Lownie, Jr., Battelle Memorial Institute, Columbus, Ohio. W. C. Jeffery, McWane Cast Iron Pipe Co., Birmingham, Ala.

Heat Treatment of Cast Iron—P. H. Dirom, Jr., Lynchburg Foundry Co., Lynchburg, Va.

Ladle Additions to Hypoeuctectic Gray Cast Iron—D. D. McGrady, H. L. Womochel, Michigan State University, East Lansing, and C. L. Langenberg, Oldsmobile Div., Lansing, Mich., D. J. Harvey, Research Laboratory, G.M.C., Detroit.

Effect of Inoculation on Risering of Gray Iron—Progress Report on Gray Iron Research, sponsored by AFS Training & Research Institute—H. D. Merchant, J. F. Wallace, Case Institute of Technology.

PLANT AND PLANT EQUIPMENT SESSION

Room 101, Convention Hall

Presiding—J. Thomson, East Chicago, Ind., H. W. Johnson, Wells Mfg. Co., Skokie, Ill.

Shell Mixing Processes and Equipment for Quality Control of Resin Coated Sand—J. Albanese, Acme Resin Co., Forest Park, Ill.

STEEL SESSION

Room A, Convention Hall

Presiding—S. E. Wolosin, Lebanon Steel Foundry, Lebanon, Pa.

Properties and Applications of Centrifugally Cast Steel Tubing—E. D. McCauley, American Cast Iron Pipe Co., Birmingham, Ala.

Surface Defects on Shell Molded Castings—R. W. Heine, University of Wisconsin, Madison, Wis., J. A. Behring, The Vollrath Co., Sheboygan, Wis.

Management by Objective—R. W. Wilson, American Hoist & Derrick Co., St. Paul, Minn.

3:00 PM

DIE CASTING AND PERMANENT MOLD SESSION

Room B, Convention Hall

Presiding—G. T. Piper, Hoover Co., North Canton, Ohio. K. W. Molder, Sunbeam Corp., Chicago.

Ultra High Pressure Casting—J. L. Reiss, E. C. Kron, Doehler-Jarvis Div., National Lead Co., Toledo, Ohio.


J. A. Behring


J. Albanese


E. C. Kron


R. W. Wilson


M. L. Kohn


J. L. Reiss

Wednesday, May 11

A Fundemental Review of Die Steels, Their Heat Treatment and Related Problems–D. R. Edgerton, N. O. Kates, Lindberg Steel Treating Co., Melrose Park, Ill.

Corrosion–Fatigue in Two Hot Work Die Steels–D. N. Williams, M. L. Kohn, R. M. Evans, R. I. Jaffee, Battelle Memorial Institute, Columbus, Ohio.

Molten Metal Handling in Die Casting Plants–V. D. Sweeny, Metal Pumping Services, Inc., Cleveland.

4:00 PM

INDUSTRIAL ENGINEERING AND COST SESSION

Room 101, Convention Hall

Presiding–J. A. Westover, Westover Corp., Milwaukee. J. Taylor, Norris & Elliott, Inc., Columbus, Ohio.

Analysis of the Incentive Questionnaire–M. T. Sell, Sterling Foundry Co., Wellington, Ohio.

Work Measurement–Pour and Shakeout–R. S. Casciari, Lebanon Steel Foundry, Lebanon, Pa.

SAND SESSION

Ballroom, Convention Hall

Presiding–R. H. Jacoby, St. Louis Coke & Foundry Supply Co., St. Louis. E. H. Berry, Dodge Steel Co., Philadelphia.

Effect of Ramming & Clay Content on Hot Compressive Strength of Molding Sand–R. W. Heine, W. Shaw, University of Wisconsin, Madison, and J. S. Schumacher, E. H. King, Hill & Griffith Co., Cincinnati.

The Phenolic Resin Bond in Solid Sand Cores–H. K. Salzberg, J. J. Greaves, Borden Chemical Co., Bainbridge, N. Y.

STEEL SESSION

Room A, Convention Hall

Presiding–C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala. R. L. Lord, Wehr Steel Co., Milwaukee.

Heat Treatment of Mn-V-Mo Age Hardenable Austenitic Steel–N. C. Howells, E. A. Lange, U. S. Naval Research Laboratory, Washington, D. C.

Impact Resistance of Nickel-Manganese Cast Steels–I. B. Elman, R. D. Schelleng, International Nickel Co., Bayonne, N. J.

Effect of Homogenizing Treatments on Structure, Properties and Transformations of a High Strength, Low Alloy Cast Steel–A. M. Ayvazian, Watertown Arsenal, Watertown, Mass., M. C. Flemings, H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

5:30 PM

EXHIBITS CLOSE

7:00 PM

AFS ANNUAL BANQUET

Ballroom, Sheraton Hotel

Presiding–AFS President Charles E. Nelson.

Presentation of AFS Gold Medal Awards.

Guest Speaker–Dr. Bergen Evans, Professor of English, Northwestern University, Evanston, Ill.

Subject–Where Do We Go With Brains?

Thursday, May 12

7:30 AM

AUTHORS–CHAIRMEN BREAKFAST

Pennsylvania East Room, Sheraton Hotel

8:30 AM

REGISTRATION OPENS (to 5:30 pm)

9:00 AM

LADIES' REGISTRATION OPENS (to 3:00 pm)

EXHIBITS OPEN

9:30 AM

DIE CASTING AND PERMANENT MOLD SESSION

Room B, Convention Hall

Presiding–C. B. Curtis, Maytag Co., Newton, Iowa. G. V. Shomos, Howard Foundry Co., Chicago.

A Brief Outline of British Die Casting Practice in Aluminum Alloys–R. R. Woodward, H. J. Proffitt, High Duty Alloys Ltd., Buckinghamshire, England. –officially sponsored by the Institute of British Foundrymen.

Low Pressure Die Casting–E. C. Lewis, Alumasc, Ltd., Northamptonshire, England.

Low Pressure Permanent Mold Casting of Aluminum–D. J. Flynn, Chevrolet Motor Div., G.M.C., Massena, N. Y.



H. K. Salzberg



N. C. Howells



J. J. Greaves



R. M. Evans



M. T. Sell



H. F. Taylor

DUCTILE IRON SESSION

Room 101, Convention Hall

Presiding—C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala. G. Krumlauf, Republic Steel Corp., Cleveland.

Symposium on Ductile Iron Quality Control Methods.

Panel—G. F. Thomas, Deere & Co., Moline, Ill., D. L. Crews, James B. Clow & Sons, Inc., Coshocton, Ohio, S. F. Levy, H. P. Deuscher Co., Hamilton, Ohio, H. W. Ruf, Grede Foundries, Inc., Milwaukee.

FUNDAMENTAL PAPERS SESSION

Room 200, Convention Hall

Presiding—M. C. Flemings, Massachusetts Institute of Technology, Cambridge. S. Lipson, Frankford Arsenal, Philadelphia.

Solidification of Aluminum Casting Alloys—R. E. Spear, G. R. Gardner, Aluminum Co. of America, Cleveland.

Precision Casting Mold Materials—W. G. Lawrence, Alfred University, Alfred, N. Y.

Grain Refinement of Copper Alloys—G. C. Gould, G. W. Form, J. F. Wallace, Case Institute of Technology, Cleveland.

Hot Tearing in Nonferrous Binary Alloys—R. A. Rosenberg, M. C. Flemings, H. F. Taylor, Massachusetts, Institute of Technology, Cambridge, Mass.

NATIONAL CASTINGS COUNCIL

Rittenhouse Room, Warwick Hotel

STEEL SESSION

Room A, Convention Hall

Presiding—L. Fink, Electric Steel Foundry Co., Portland, Ore. W. M. Spear, Worthington Corp., Harrison, N. J.

Stainless Steel Arc Melting Practice, S. E. Wolosin, Lebanon Steel Foundry, Lebanon, Pa.

The Economics of Quality Acid Steel Making Practice—C. F. Christopher, Blaw-Knox Co., East Chicago, Ind.

Basic Oxygen Steelmaking—Some Speculations on Steel Foundry Applications—F. E. VanVoris, Union Carbide Metals Co., Div. Union Carbide Corp., Cleveland.

12:00 NOON

JOINT GRAY IRON AND DUCTILE IRON ROUND TABLE LUNCHEON

Auditorium, Convention Hall

Presiding—H. H. Wilder, Vanadium Corp. of America, Chicago. W. A. Wright, Woodruff & Edwards, Inc., Elgin, Ill.

Scrap Metal for Iron Foundry Use—W. S. Story, Institute of Scrap Iron & Steel, Washington, D. C.

NATIONAL CASTINGS COUNCIL LUNCHEON

Green Room, Warwick Hotel

PAST PRESIDENTS' LUNCHEON

Valley Forge Room, Warwick Hotel

Presiding—L. H. Durdin, Dixie Bronze Co., Birmingham, Ala.

STEEL ROUND TABLE LUNCHEON

Room 300, Convention Hall

Presiding—D. N. Rosenblatt, American Foundry & Machine Co., Salt Lake City.
J. A. Rassenfoss, American Steel Foundries, East Chicago, Ind.

Progress Report on Steel Research, sponsored by AFS Training and Research Institute.

Nonmetallic Macroinclusion Causes in Steel Castings Deoxidized with Aluminum—L. H. VanVlack, R. A. Flinn, University of Michigan, Ann Arbor, Mich., G. A. Colligan, United Aircraft Corp., East Hartford, Conn.

Reactions between Refractories and Molten Steel Containing Aluminum—L. H. VanVlack, R. A. Flinn, University of Michigan, Ann Arbor, Mich.

2:00 PM

DIE CASTING AND PERMANENT MOLD SESSION

Room A, Convention Hall

Presiding—A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Inc., Chicago. B. J. Murray, Jr., Apex Smelting Co., Chicago.

Aluminum Casting Alloys Improvement by Grain Refinement—K. Schneider, Aluminiumwerke Nuernberg G.m.b.H., Nuernberg, Germany.

Aluminum Alloy with High Silicon Content—E. E. Stonebrook, Aluminum Co. of America, Cleveland.

DUCTILE IRON SESSION

Room 101, Convention Hall

Presiding—D. Matter, Ohio Ferro Alloys Corp., Canton, Ohio. S. Carter, American Cast Iron Pipe Co., Birmingham, Ala.



R. R. Woodward



W. G. Lawrence



G. C. Gould



H. J. Proffitt



E. E. Stonebrook



K. Schneider

Thursday, May 12

Influence of Nickel up to 37% and Silicon up to 3% on the Eutectic Carbon Content of Cast Iron—

R. D. Schelleng, International Nickel Co., Bayonne, N. J.

Manufacture and Quality Control Methods for Shell Molded Nodular Iron Castings at the Ford Motor Co.—H. C. Grant, A. A. Adams, Ford Motor Co., Dearborn, Mich.

SYMPOSIUM ON SOLIDIFICATION

Jointly Sponsored by Fundemental Papers and Heat Transfer Committees.

Room B, Convention Hall

Presiding—R. C. Shnay, Canada Iron Foundries, Ltd., Toronto, Ont., Canada. W. K. Bock, National Malleable & Steel Castings Co., Cleveland.

Solidification of Metals—General Principles—G. W. Form, J. F. Wallace, Case Institute of Technology, Cleveland.

Solidification of Steel Castings—C. W. Briggs, Steel Founders' Society of America, Cleveland.

Solidification of Cast Iron—C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala.

Solidification of Aluminum Castings—M. C. Flemings, S. Z. Uram, H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

Solidification of Copper Alloy Castings—R. W. Ruddle, Foundry Services, Inc., Cleveland.

Solidification of Metals—A Summary—W. K. Bock, National Malleable & Steel Castings Co., Cleveland.

4:00 PM

GRAY IRON SESSION

Room 200, Convention Hall

Presiding—M. H. Horton, Deere & Co., Moline, Ill.

Symposium—Hot Blast in Gray Iron Melting.

Panel—W. J. Sommer, The Plainville Casting Co., Plainville, Conn. D. B. Ziegler, W. O. Larson Foundry Co., Grafton, Ohio. T. Giszczak, Central Foundry Div., G.M.C., Defiance, Ohio. R. Dekker, James B. Clow & Sons, Inc., Bensenville, Ill.

SAND SESSION

Ballroom, Convention Hall

Presiding—O. J. Myers, Reichhold Chemicals, Inc., White Plains, N. Y. H. W. Meyer, General Steel Castings Co., Granite City, Ill.

Density-Sand Grain Distribution Effect on Physical Properties—T. W. Seaton, American Silica Sand Co., Inc., Ottawa, Ill.

The Use of the Shatter Test for Controlling Clay-Bonded Sand—W. B. Parkes, R. G. Godding, British, Cast Iron Research Association, Birmingham, England—officially sponsored by B.C.I.R.A.

A Systematic Approach to Foundry Sand Design and Control—A. H. Zrimsek, G. J. Vingas, Magnet Cove Barium Corp., Arlington Heights, Ill.

STEEL SESSION

Room A, Convention Hall

Presiding—H. L. Kurtz, Empire Steel Casting Co., Reading, Pa. E. W. O'Brien, Oklahoma Steel Castings Co., Tulsa, Okla.

Castings for Replacement of Forgings and Fabrications at High Strength Levels—H. H. Harris, General Alloys Co., Boston.

Some Metallurgical Factors Influencing Austenitic Manganese Steels—T. E. Norman, D. V. Doane, A. Solomon, Climax Molybdenum Co. of Michigan, Detroit.

5:30 PM

EXHIBITS CLOSE

7:00 PM

AFS ALUMNI DINNER

Washington and Adams Rooms, Warwick Hotel

Presiding—Past-President L. H. Durdin, Birmingham, Ala. (For AFS Alumni only)

8:00 PM

DUCTILE IRON SHOP COURSE

Hall of Flags, Sheraton Hotel

Presiding—A. J. Fruchtl, James B. Clow & Sons, Inc., Coshocton, Ohio.

Subject—Methods of Alloying.

Panel—R. Carlson, American Cast Iron Pipe Co., Birmingham, Ala. H. E. Henderson, Lynchburg Foundry Co., Lynchburg, Va. D. Sanner, Cooper-Bessemer Corp., Mt. Vernon, Ohio.

GRAY IRON SHOP COURSE

Pennsylvania Center Room, Sheraton Hotel

Presiding—D. E. Matthieu, Wysong & Miles Foundry, Inc., Greensboro, N. C. E. Beyerlein, Fuller Mfg. Co., Kalamazoo, Mich. K. H. Priestley, Vassar Electroloy Products, Inc., Vassar, Mich.

Subject—Fundemental Behavior of Gray Iron—
Shrinkage and Mold Wall Movement.
Feeding Distances.
Mechanical Properties and Structure.

Speaker—H. L. Womochel, Michigan State University, East Lansing, Mich.


W. B. Parkes


D. V. Doane


T. E. Norman


A. Solomon


S. E. Wolosin


R. G. Godding

Friday, May 13

7:30 AM
AUTHORS–CHAIRMEN BREAKFAST

Pennsylvania East Room, Sheraton Hotel

8:30 AM
REGISTRATION OPEN (to 5:00 pm)

9:00 AM
EXHIBITS OPEN (to 5:00 pm)

Philadelphia Day.
(Free admission for employees of Philadelphia area plants).

9:30 AM
DUCTILE IRON SESSION

Room 101, Convention Hall

Presiding H. W. Ruf, Grede Foundries, Inc., Milwaukee.
W. Levi, Radford, Va.

Panel–Gating and Risering of Ductile Iron.
Effect of Composition of Nodular Iron on their Gating and Risering Characteristics–J. A. Davis, Battelle Memorial Institute, Columbus, Ohio.
Gating and Risering of Green Sand Ductile Iron Castings–J. C. McCartney, John Deere Malleable Works, East Moline, Ill.
Gating and Risering of Ductile Iron Castings in Dry Sand Molds–D. M. Marsh, Cooper-Bessemer Co., Mt. Vernon, Ohio.
Gating and Risering Shell Molded Ductile Iron Castings–H. O. Meriwether, Lynchburg Foundry Co., Lynchburg, Va.

FUNDAMENTAL PAPERS SESSION

Room A, Convention Hall

Presiding–J. F. Wallace, Case Institute of Technology, Cleveland.
P. J. Ahearn, Watertown Arsenal, Watertown, Mass.

Some Considerations in the Kinetics of Dephosphorization and Desulphurization of Basic Electric Steels–J. Zotos, E. DeLucca, Watertown Arsenal, Watertown, Mass.

Desulphurization by Calcium Injection Improves Properties of Cast Steel–D. A. Collins, P. J. Ahearn, Watertown Arsenal, Watertown, Mass.

Effect of Structure and Microporosity on Mechanical Properties of High Strength Cast Steel–S. Z. Uram, M. C. Flemings, H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

Vacuum Induction Melting of High-Strength Steels–P. J. Ahearn, Watertown Arsenal, Watertown, Mass., P. S. Schaffer and M. C. Flemings, Massachusetts Institute of Technology, Cambridge, Mass.

HEAT TRANSFER SESSION

Room 200, Convention Hall

Presiding–R. W. Ruddle, Foundry Services, Inc., Cleveland. W. K. Bock, National Malleable & Steel Castings Co., Cleveland.

Measurement Versus Calculation of Solidification of Metal in Iron Molds–J. D. Keller, Associated Engineers, N. R. Arant, Roll Manufacturers Institute, Pittsburgh, Pa.

Demonstration of the Analogue Computer–V. Paschkis, Columbia University, New York.

Gap Formation in Permanent Mold Castings–J. G. Henzel, J. Keverian, General Electric Co., Schenectady, N. Y.

SAND SESSION

Ballroom, Convention Hall

Presiding–H. C. Winte, Florence Pipe Foundry & Machine Co., Florence, N. J. E. C. Zirzow, Werner G. Smith, Inc., Cleveland.

Selected Principles of Soil Mechanics Related to Sand Testing, Molds and Cores–D. C. Williams, Ohio State University, Columbus, Ohio.

Effect of Variation of Some Physical and Chemical Conditions on Properties of Bentonite Suspensions–A. J. Anderson, G. J. Sutton, University of New South Wales, Sidney, Australia.

Casting Loss Reduction Program–H. W. Dietert, Harry W. Dietert Co., Detroit.

EXHIBITS CLOSE

LADIES' PROGRAM

Registration will be held daily except Friday at the Pink and Gold Room, second floor, Bellevue Stratford Hotel.

MONDAY, MAY 9 3:00 pm

OFFICIAL AFS TEA

Terrace Garden, Benjamin Franklin Hotel

TUESDAY, MAY 10 Noon

LUNCHEON AND STYLE SHOW.

Burgandy Room, Bellevue Stratford Hotel

WEDNESDAY, MAY 11

A free day for the ladies.

THURSDAY, MAY 12 10:00 am

Bus tour of historical gardens enroute to DuPont Longwood gardens. Luncheon at DuPont Hotel.


N. R. Arant


S. Z. Uram


M. C. Flemings


H. W. Dietert


V. Paschkis


J. D. Keller



Hoyt Lecturer

William J. Grede is president of J. I. Case Co., Racine, Wis., and chairman of the board, Grede Foundries, Inc., Milwaukee, a group of seven foundries located in Wisconsin, Michigan and Indiana. He has been active in trade and business associations and served as president of the National Association of Manufacturers in 1952. In 1946 he was awarded the AFS McFadden Gold Medal for . . . "Outstanding public service bringing great credit upon and broad recognition for the entire foundry industry."

Host Committees

A hearty welcome to an estimated 15,000 foundrymen attending the AFS Castings Congress & Exposition is being extended by the General Convention Committee of the Philadelphia Chapter, host chapter to the annual convention.

Heading the general committee are General Convention Chairman Clyde B. Jenni, General Steel Castings Corp., Eddystone, Pa.; General Convention Vice-Chairman Henry C. Winte, Florence Pipe Foundry & Machine Co., Florence, N.J.; and Secretary-Treasurer Herman E. Mandel, Pennsylvania Foundry Supply & Sand Co., Philadelphia.

Reception

Chairman—J. M. Robb, Jr., Pennsylvania Foundry Supply & Sand Co. . . H. N. Albright, Grinnell Corp. . . E. C. Benkert, Fairmount Foundry Co. . . A. S. Breithaupt, Dodge Steel Co. . . W. A. Brown, Florence Pipe Foundry & Machine Co. . . J. S. Saaklos, Crucible Steel Castings Co. . . D. J. Davis, General Steel Castings Corp. . . H. G. Enderlein, H. G. Enderlein Co. . . W. F. Faison, Atlantic Steel Castings Co. . . W. W. Goessel, Beloit Eastern Corp. . . H. P. Good, Textile Machine Works. . . C. D. Hamburg, Bonair Foundry Co. . . P. J. Keeley, Northern Bronze Co. . . K. H. Kostenbader, Bethlehem Steel Co. . . W. H. Lipponcott, Crown Non-Ferrous Foundry, Inc. . . Donald MacBrien, Philadelphia Coke Co. . . C. P. Speitel, Pennsylvania Malleable Iron Corp. . . A. A. Thum, Palmyra Foundry Co. . . T. R. Walker, Jr., U.S. Pipe & Foundry Co. . . C. R. Wolf, New Jersey Silica Sand Co. . . H. R. Williams, George F. Pettinos, Inc.

Plant Visitation

Chairman—C. W. Mooney, Olney Foundry Div., Link-Belt Co. . . E. J. Bonesteel, Eastern Malleable Iron Co. . . C. H. Cline, H. G. Enderlein Co. . . H. E. Edsall, Birdsboro Corp. . . R. J. Fitzgerald, Daniel Goff Co. . . E. N. Garrett, Kitson Valve Div., Welsbach Corp. . . J. R. Gionti, Williamstown Foundry Corp. . . Hans Jacob, Lehigh Foundries Co. . . P. J. Keeley, Northern Bronze Co. . . W. A. Morley, Olney Foundry Div., Link-Belt Co. . . F. T. Schaefer, Philadelphia Coke Co. . . Charles Sweeny, Atlantic Steel Castings Co. . . D. J. Volk, Alloy Steel Casting Co. . . W. A. Wood, Florence Pipe Foundry & Machine Co.



C. B. Jenni, Chairman General Convention Committee



H. C. Winte, Vice-Chairman General Convention Committee



H. E. Mandel, Sec.-Treas. Committee General Convention



J. M. Robb, Chairman Reception Committee



C. W. Mooney, Chairman Plant Visitation Committee

Banquet Speaker

Dr. Bergen Evans, professor of English at Northwestern University, Evanston, Ill., is well known through his frequent contributions to magazines, his television appearances and his books. Active in television since 1948, he was given the Peabody award in 1958 for his role as moderator on "The Last Word." Dr. Evans supplied the questions for "The $64,000 Question" and "The $64,000 Challenge," and moderated "Down You Go." He has been a member of the English Department at Northwestern University since 1932.



Shop Course

Chairman—R. F. Schmidt, Ajax Metal Div., H. Kramer Co. . . W. Burrows, Atlantic Steel Castings Co. . . C. H. Cline, H. G. Enderlein Co. . . R. F. Foster, Link-Belt Co. . . W. M. Grafford, General Steel Castings Corp. . . W. M. Grimm, William Grimm Brass Foundry Co. . . F. J. Haines, Stanley G. Flagg & Co. . . L. A. Houser, Dodge Steel Co. . . M. J. Lippincott, Florence Pipe Foundry & Machine Co. . . F. L. Mattson, Hickman, Williams & Co. . . C. E. Muller, Ingesoll-Rand Co. . . A. L. Proctor, Bethlehem Steel Co. . . P. K. Reinginger, Textile Machine Works. . . C. P. Rider, Grinnell Corp. . . . R. E. Rosien, Eastern Malleable Iron Co. . . A. E. Schuh, U.S. Pipe & Foundry Co. . . J. W. Swengel, American Chain & Cable Co. . . J. Terrill, Pennsylvania Malleable Iron Corp. . . R. Weller, Beloit Eastern Corp.

Banquet

Chairman—W. J. Gallana, E. J. Lavino & Co. . . E. C. Anderson, Republic Steel Corp. . . R. M. Carrigan, North American Smelting Co. . . J. J. Ediston, U.S. Graphite Co., Div. Wickes Corp. . . C. E. Gillespie, Debevoise-Anderson Co. . . F. J. Keeley, H. Kramer & Co. . . S. C. Kirn, M. L. Kirn & Bro., Inc. . . H. B. Mandel, Pennsylvania Foundry Supply & Sand Co. . . R. P. Patterson, Olney Foundry Div., Link-Belt Co. . . J. E. Quigley, National Crucible Co. . . S. A. Schilling, American Smelting & Refining Co.

Ladies Entertainment

Co-Chairmen—Mrs. R. C. Stokes, Mrs. E. A. Zeeb. . . Mrs. C. B. Jenni. . . Mrs. H. E. Mandel. . . Mrs. C. W. Mooney, Mrs. R. F. Schmidt. . . Mrs. E. C. Klank.

Philadelphia Day

Chairman—E. C. Klank, Lancaster Foundry Supply Co. . . D. E. Best, Bethlehem Steel Co. . . A. H. Ciaglia, G. E. Smith, Inc. . . A. J. Derrick, Palmyra Foundry Co. . . A. W. Johnson, Debevoise-Anderson Co. .. A. W. Lang, Universal Rundle Corp. . . J. W. Mentzer, Lancaster Foundry Supply Co. . . T. F. Miller, Schneider, Bowman Co. . . Harry Reitinger industrial engineer. . . E. J. Shields, Olney Foundry Div., Link-Belt Co. . . G. H. Smith, Florence Pipe Foundry & Machine Co. . . Jack Sokol, Wilkening Mfg. Co. . . W. S. Thomas, Emmaus Foundry & Machine Co. . . Donald Volk, Alloy Steel Casting Co.



R. F. Schmidt, Chairman
Shop Course Committee



W. J. Gallana, Chairman
Banquet Committee



Mrs. E. A. Zeeb,
Co-Chairman
Ladies Entertainment



Mrs. R. C. Stokes,
Co-Chairman
Ladies Entertainment



E. C. Klank, Chairman
Philadelphia Day

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A. J. MOORE



W. H. OLIVER



J. R. RUSSO



C. A. SANDERS



A. M. SLICHTER



H. G. STENBERG

Terms Expire 1960

W. D. Dunn
L. H. Durdin
A. A. Hochrein
K. L. Landgrebe, Jr.
F. J. Pfarr
J. R. Russo
A. M. Slichter
H. G. Stenberg

Terms Expire 1961

D. W. Boyd
R. R. Deas, Jr.
J. Dee
W. L. Kammerer
D. E. Matthieu
H. M. Patton
C. A. Sanders

Terms Expire 1962

N. N. Amrhein
D. L. Colwell
R. E. Mittlestead
A. J. Moore
W. H. Oliver
C. E. Jeter
J. N. Wessel

Gold Medal Awards



SAMUEL F. CARTER, JR.
Mr. Carter, American Cast Iron Pipe Co., Birmingham, Ala., is winner of the **Wm. H. McFadden Gold Medal** . . . "For exceptional contributions to AFS and the castings industry in the fields of cupola melting, electric steel melting and control.



WALDECK W. LEVI
Mr. Levi, consulting metallurgist, Radford, Va., is winner of the **Thomas W. Pangborn Gold Medal** . . . "For outstanding contributions to the Society and the ferrous castings industry in the fields of cupola metallurgy, research and operations."



THERON D. STAY
Mr. Stay, Reynolds Metals Co., Cleveland, is winner of the **Joseph S. Seaman Gold Medal** . . . "For outstanding technical contributions to the Society and the light metals industry over many years, particularly in alloying and casting."

Awards of Scientific Merit

GEORGE P. HALLIWELL
Mr. Halliwell, H. Kramer & Co., Chicago, is recognized . . . "For noteworthy achievements in the field of brass and bronze casting, and for outstanding technical services to the Society."

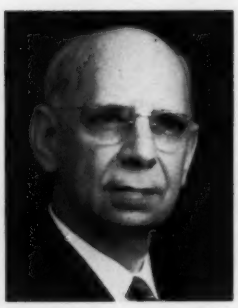




GEORGE A. TIMMONS
Mr. Timmons, Climax Molybdenum Co., Detroit, is recognized . . . "For notable contributions and services to AFS and the ferrous foundry industry in the fields of heat treatment and alloying of gray iron."

Service Citations

WILLIAM M. BALL, JR.
Mr. Ball, R. Lavin & Sons, Inc., Chicago, is recognized . . . "For outstanding and inspirational services to AFS, its Chapters and the non-ferrous castings industry over the many years."





VICTOR E. ZANG
Mr. Zang, Unitcast Corp., Toledo, Ohio, is recognized . . . "For tireless and continuous efforts on behalf of AFS and the steel castings industry in promotion of cooperative technical endeavor."



OFFICIAL GUIDE TO EXHIBITS

AFS

FOUNDRY EXPOSITION

Acme Resin Corp., Forest Park, Ill. (Booth No. 908). Shell core and mold resins, resin coated sands, shell mold bonding resins, resin core binder.

Adams Co., Dubuque, Iowa. (Booth No. 317). Cherry and aluminum flasks, upsets, jackets, bands, molding machines, accessories.

A. I. C. Engineering Co., Indianapolis. (Booth No. 716). Liners for: tumbling mills, table and tumble blast equipment, shot blast rooms and other foundry applications.

Air Reduction Co., see Pure Carbonic Div.

Ajax Magnethermic Corp., Youngstown, Ohio. (Booth No. 1109-1111). Cage-type high frequency furnace, core-type 60-cycle furnace, console-type power and control unit, power sources for induction melting, 180-cycle frequency convertor, vertical motor generator unit.

Ajax Metal Div., H. Kramer & Co., Philadelphia. (Booth No. 818). Brass, bronze, nickel silver ingots, special alloys, hardeners, copper shot, phosphor copper shot and waffle.

Alan Wood Steel Co., Conshohocken, Pa. (Booth No. 911). Pig iron, foundry coke, iron powder, melting stock briquets.

Allied Chemical Corp., see Semet Solvay.

Alloy Metal Abrasive Co., Ann Arbor, Mich. (Booth No. 1135). Shot and grit, blast machine parts.

Alphaco, Inc., York, Pa. (Booth No. 923). CO_2 vacuum gassing machines, CO_2 pressure gassing machines, sand reclamation unit for synthetic, CO_2 and resin bonded sands.

Alpha-Lux Co., New York. (Booth No. 406). Moisture tester, ladle lining for malleable, gray iron and steel.

Aluminium Ltd. Sales, Inc., see Apex Smelting Co.

American Air Filter Co., Louisville, Ky. (Booth No. 934-936). Dust control equipment and accessories.

American Colloid Co., Skokie, Ill. (Booth No. 616). Bonds and raw materials for foundry sands.

American Foundry Flask Co., Kansas City, Mo. (Booth No. 410). Fabricated steel flasks, bottom boards, core plates, steel jackets, upsets, pins and bushings.

American Marietta Co., see Hydro-Blast Div., Guardite Co. and Presstite Div.

American Metal Market Co., New York. (Booth No. 715). Daily newspaper for metal industries.

American Refractories & Crucible Corp., North Haven, Conn. (Booth No. 1010). Crucibles, graphite products, insulating materials, refractories.

American Smelting & Refining Co., see Federated Metals Div.

Apex Smelting Co., Chicago. (Booth No. 937-939). Aluminum alloy ingot, pig and shot; magnesium alloys and zinc base alloys. Also foundry alloys.

Arcair Co., Lancaster, Ohio. (Booth No. 1239). Metal removal torches, pad washing torches, electrodes, recorders, smoke and fume exhausters, surface protection compound, AC welding torch and cored electrodes, welding carbon products.

Archer-Daniels-Midland Co., Cleveland. (Booth No. 1204-1206-1208). Binders for oil-sand cores, special purpose binders, foundry resins for oven or dielectric baked sand cores, resins for shell cores and molds, sea coal and pitch facings, western bentonite, sand stabilizers, washes and blackings, mold partings, foundry supplies.

Atlas Copco Co., New York. (Booth No. 1422). General-purpose air compressors with compressed air being supplied to other exhibitors' pneumatic equipment.
Aurora Metal Co., see Faskure Div.

Baird-Atomic, Inc., Cambridge, Mass. (Booth No. 1235). Complete line of chemical instruments for emission and infrared spectroscopy. New infrared spectrophotometer. Complete line of new infrared accessories.

Balsam Gap Co., Subsidiary of E. J. Lavino & Co., Philadelphia. (Booth No. 436). Olivine rock used in making foundry sand.

Baroid Chemicals, Inc., Div. National Lead Co., Houston, Texas. (Booth No. 928). Operating foundry demonstrating waterless bonding agent for molding sands.

C. O. Bartlett & Snow Co., Cleveland. (Booth No. 1515). Sand, mold and castings handling equipment.

Basic Products Corp., see Hevi-Duty Electric Co. Div. and Como-Cast Corp. Div.

Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago. (Booth Nos. 1215-1219-1221-1223-1225-1314-1318-1320-1322-1324-1319-1321-1323). Sandlingers, automatic sandslingers, electrical and electronic controls; core, molding and shell sand mixers; laboratory mixers; stationary and portable sand preparators; sand conditioning machines; electric riddles; pneumatic sand reclamation equipment; CO_2, shell and conventional sand blowers; automatic CO_2 gassing machines; mold and core draw and rollover draw machines; jolt, jolt-strip, jolt-squeeze and jolt rollover machines; shell molding machines; shakeout equipment; wire straighteners; wire cutters; foundry trucks.

Bekaert Steel Wire Corp., New York. (Booth No. 238). Steel wire shot made of high carbon steel wire.

Beryllium Corp., Reading, Pa. (Booth No. 925). Display of cast beryllium copper products, produced in sand, plaster and shell molds and by pressure, Shaw and investment casting.

Bigelow-Garvey Lumber Co., Chicago. (Booth No. 431). Wooden containers for bulk handling and storage.

Blastcrete Service Co., Los Angeles. (Booth No. 405). Cupola and refractory guns, angle nozzle.

Blaw-Knox Co., Pittsburgh, Pa. (Booth No. 124). Clamshell buckets for foundry service.

British Industries Corp., see Shaw Process Development Corp.

British Moulding Machine Co., Ltd., Faversham, Kent, England. (Booth No. 102-106-201-205). Turnover and straight draw molding machines, the latter exhibited as a cope and drag production unit with drag turnover and closing.

Brown Metals, Inc., Elyria, Ohio. (Booth No. 1210). Foundry engineering services and/or on-the-job operational assistance on plant layout, melting equipment and practice, metal handling, metallurgy and process control. Also hot-blast heaters for cupolas.

Brush Beryllium Co., Cleveland. (Booth No. 506). Beryllium alloy castings, metal-beryllium oxide refractions, copper rolled strip, beryllium metal machined shapes, beryllium oxide sintered shapes, beryllium nickel blow mold for glass.

The Budd Co., see Carbonyl Metal Products Div.

C&S Products Co., Detroit. (Booth No. 903-907-909-1004-1006). Shell and sand

coating equipment, shell blowing machines, stock core machine, belt conveyor and bucket elevators.

Campbell-Hausfeld Co., Harrison, Ohio. (Booth No. 935). Non-ferrous metal melting furnaces, gas or oil fired, tilting or stationary types.

Carbonyl Metal Products Div., The Budd Co., Philadelphia. (Booth No. 501). Carbonyl nickel patterns, core boxes, shell molds and production technique.

Carborundum Co., Niagara Falls, N. Y. (Booth No. 1110). Ferrocarbo briquets and grain.

Cardox Div., Chemetron Corp., Chicago. (Booth No. 1009). Low pressure carbon dioxide storage demonstration tank, dual-shield welder.

Carrier Conveyor Div., Chain Belt Co., Louisville, Ky. (Booth No. 1025-1124). Conveying equipment and accessories, engineering services, material handling equipment and accessories, sand handling and conditioning equipment and accessories.

Carver Foundry Products, Muscatine, Iowa. (Booth No. 1536-38). Equipment and supplies for CO_2 process, mullers, automatic core shooters, mold stations, gassing.

Centrifugal Casting Machine Co., Tulsa, Okla. (Booth No. 502). Centrifugal casting machines, vacuum degassers, permanent molds.

Chain Belt Co., see Carrier Conveyor Div.
Chemetron Corp., see Cardox Div.

Clearfield Machine Co., Clearfield, Pa. (Booth No. 1002). Mixers and loader, operating exhibit in conjunction with Royer Foundry & Machine Co.

Cleveland Flux Co., Cleveland. (Booth No. 1504). Iron, semi-steel, malleable, brass, bronze, aluminum and ladle fluxes.

Cleveland Metal Abrasive Co., Cleveland. (Booth No. 1106). Shot and grit including steel, malleable, chilled iron, cut wire.

Cleveland Vibrator Co., Cleveland. (Booth No. 330). Air and electric vibrators, air-powered vibratory feeders, operating models of vibratory feeders and conveyors.

Como-Cast Corp., Div. Basic Products Corp., Milwaukee. (Booth No. 1437-1439). Automatic aluminum, brass casting units.

Connecticut Coke Co., New Haven, Conn. (Booth No. 1133). Coke.

Cooper-Chapman, Ltd., Toronto, Ont. Canada. (Booth No. 1634). Automatic and manual shell core blowers.

Corn Products Sales Co., New York. (Booth No. 1410). Cereal core binders, dry core binders, dextrose, liquid core binders.

Davenport Machine & Foundry Co., Davenport, Iowa. (Booth No. 910). Foundry molding machines.

Davey Compressor Co., Kent, Ohio. (Booth No. 1623). 2-100 hp rotary air compressors, supplying compressed air to exhibitors.

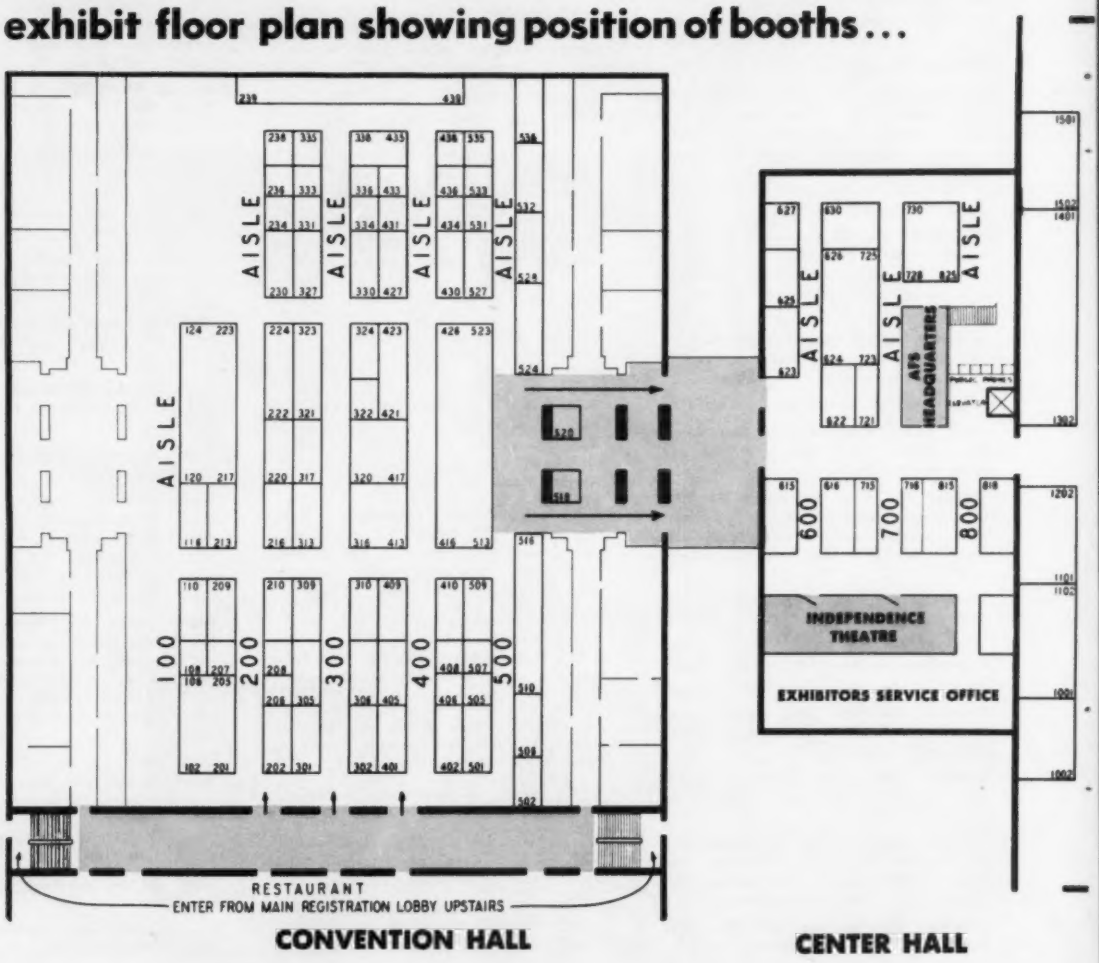
Davis Fire Brick Co., Columbus, Ohio. (Booth No. 723). Cupola and ladle linings, brick and plastic, carbon plastic, castables and cements.

Dayton Oil Co., Dayton, Ohio. (Booth No. 725). Core and mold binders, washes and pastes.

Debevoise-Anderson Co., New York. (Booth No. 509). Pig iron, coke, limestone, alloys.
Delta Oil Products Corp., Milwaukee. (Booth No. 302). Core and mold washes, sand additives, release agents, parting compounds, core oils, liquid resins, dry binders, silicate binders.

Demmler Mfg. Co., Kewanee, Ill. (Booth No. 1525). Shell core blowing machine,

exhibit floor plan showing position of booths...



oil sand core blowing and core shooting machine, roll-over draw machine.

Dependable Shell Core Machines, Inc., Portland, Ore. (Booth No. 915). Shell core machines and accessories.

Detroit Electric Furnace Div., Kuhlman Electric Co., Bay City, Mich. (Booth No. 920). Furnaces to melt iron, bronzes and alloys.

Deynor Corp., Mamaroneck, N. Y. (Booth No. 436). Standard and portable wet water mixers, cartridges and concentrate.

Harry W. Dietert Co., Detroit. (Booth No. 510-516). Sand, core, shell testing equipment, automated systems for bond additions, moisture control, sand cooling, sand distribution and cycling.

Dike-O-Seal, Inc., Chicago. (Booth No. 1232). Plastic rubber blow tubes and tips, ram and riser formers, pouring basins and pattern repair material, blow plate and core box seals.

Joseph Dixon Crucible Co., Jersey City, N. J. (Booth No. 402). Crucibles, cements, furnace linings, refractories, stoppers, nozzles.

Durez Plastics Div., Hooker Chemical Co., Tonawanda, N. Y. (Booth No. 527). Phenolic resins for bonding shell molds and shell cores.

Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill. (Booth No. 1529-1628). Bonding clays, sand additives, cupola lining material and refractory air placement gun.

Eastern Gas & Fuel Associates, Philadelphia Coke Div., Philadelphia. (Booth No. 1133). Metallurgical and steam coal, foundry and metallurgical coke.

Electro Refractories & Abrasives Corp., Lackawanna, N. Y. (Booth No. 1229). Crucibles, vitrified and resinoid grinding wheels, high temperature silicon carbide refractories and cements.

Electrode Div., Great Lakes Carbon Corp., New York. (Booth No. 401). Coke, crucibles, electrodes, graphite products, refractories.

Encyclopaedia Britannica, Inc., Philadelphia. (Booth No. 518). New edition of Encyclopaedia Britannica.

Exomet, Inc., Conneaut, Ohio. (Booth No. 1236). Exothermic and insulating products for ferrous and non-ferrous castings, gas detector, custom alloys.

Fanner Mfg. Co., Cleveland. (Booth No. 1103). Chaplets, chills and nails.

Foskuro Div., Aurora Metal Co., Aurora, Ill. (Booth No. 919). Resin coated sand for shell cores and shell molds.

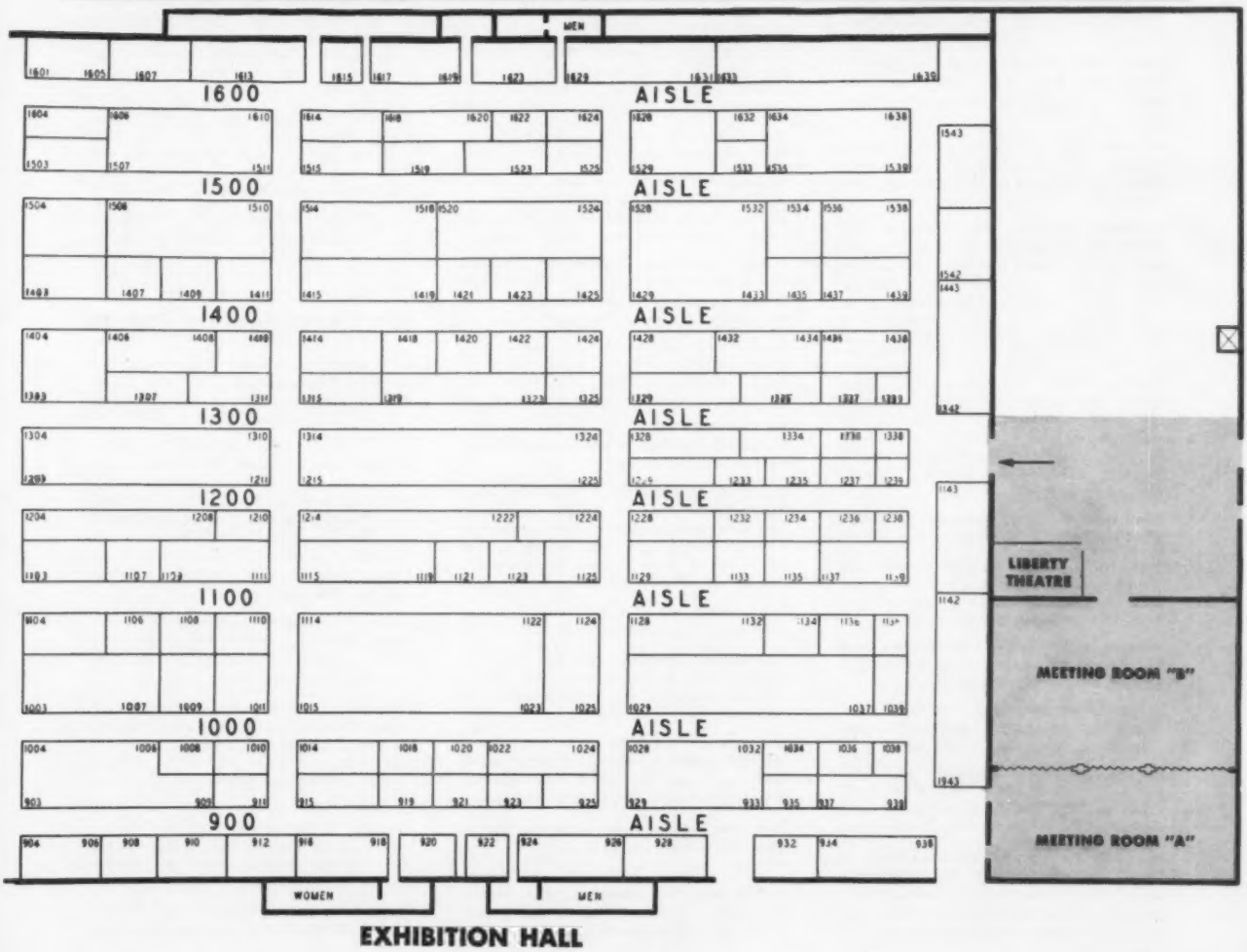
F. E. North America, Ltd., Toronto, Canada. (Booth No. 1429-1433-1528-1532). 250-ton per hr belt muller, 30 ton per hr continuous muller, ton-a-minute sand slinger, automatic molding unit, flaskless molding machine, shell core blower.

Federated Metals Div., American Smelting & Refining Co., New York. (Booth No. 421). Non-ferrous metals and alloys.

Fendall Co., Chicago. (Booth No. 409). Ductile iron cup goggles, face shields, other forms of eye protection.

FOUNDRY magazine.

Foundry Equipment Co., Cleveland. (Booth No. 1128-1132). Core and mold ovens, dielectric core ovens, high-speed mold ovens, portable mold dryers.



Foundry Services, Inc., Cleveland. (Booth No. 943-1042-1043). Fluxes, degassers, deoxidizers, mold, core and die dressings, exothermic materials.

Fox Grinders, Inc., Pittsburgh, Pa. (Booth No. 932). High speed grinding equipment, swing frame grinders, floor stand grinders, and swing frame cut-off machines.

Freeman Supply Co., Toledo, Ohio. (Booth No. 1029-1033-1035). Patternshop and foundry supplies and equipment.

Fremont Flask Co., Fremont, Ohio. (Booth No. 1338). Slip flasks, cast iron and cast aluminum jackets.

Furane Plastics, Inc., Los Angeles. (Booth No. 1535). Mass casting resins for core boxes, gel coat and laminating resins for cope and drag patterns, aluminum resin for matchplates, patching and fillet pastes, foams, adhesives and coatings.

General Dynamics Corp. see Liquid Carbonic Div.

General Refractories Co., Philadelphia. (Booth No. 210). Fire clay, high-alumina, silica and basic brick, mortars, castables, plastics, ramming mixes and bulk refractory materials, insulating fire brick and insulation.

Daniel Goff Co., Jesse S. Morie & Son, Inc., Mauricetown, N. J. (Booth No. 1138). Abrasives, clay, fire clay products, sand.
Great Lakes Carbon Corp., see Electrode Div.

Great Lakes Foundry Sand Co., Detroit. (Booth No. 614). Bank, silica and lake sands, coke, clay, abrasives, refractories, fluxes.

Guardite Co., Hydro-Blast Div., American Marietta Co., Wheeling, Ill. (Booth No. 323). Dry and wet sand reclaimers, core knock-out.

Hansberg Shooters, Inc., Evanston, Ill. (Booth No. 1003-1007). Core shooters of various sizes, bench and floor models, roll-over-stripper, CO_2-hardening machines, bench and floor models, three-station combination shooter and CO_2 hardeners, combination shooter and CO_2 gasser, core and mold making machine.

Harbison-Walker Refractories Co., Pittsburgh, Pa. (Booth No. 1443). Materials for shell, investment and ceramic shell molding, refractory media for conventional molding, specialty products for electric furnaces, malleable iron furnaces, cupolas, pouring refractories.

Harnischfeger Corp., Milwaukee. (Booth No. 1406-1408). Cranes and hoists.

Benj. Harris & Co., Chicago Heights, Ill. (Booth No. 1519). Brass, bronze and nickel silver ingot, copper-base alloys, primary aluminum alloy, pig and ingot.

Harrison Machine Co., Wesleyville, Erie, Pa. (Booth No. 1039). Shell coremaking equipment and accessories.

Hartley Controls Corp., Neenah, Wis. (Booth No. 625). Sand controls for complete automation of sand systems.

Herman Pneumatic Machine Co., Pittsburgh, Pa. (Booth No. 1415-1419). Automatic molding machines, squeeze strip machines.

Hevi-Duty Electric Co., Div. Basic Products Corp., Milwaukee. (Booth No. 1437-1439). Double-chamber dry hearth aluminum melting and holding furnaces, industrial ovens and heat treating furnaces.

Hewitt-Robins, Stamford, Conn. (Booth No. 533). Rubber spiral idler, speed reducers, conveyor belting, industrial hose and noise-deadening shakeout devices.

Hickman, Williams & Co., Philadelphia. (Booth No. 524). Foundry coke, silvery pig iron, dolomite, pig iron, shot and grit, jackets.

Hill & Griffith Co., Cincinnati. (Booth No. 1614). Core and mold washes for steel castings, release agents, "effective clay" chart for simplified sand control.

Hines Flask Co., Cleveland. (Booth No. 1407). Flasks and accessories.

Hooker Chemical Corp. see Durez Plastics Div.

Homer Mfg. Div., Ohio Electric Mfg. Co., Maple Heights, Ohio. (Booth No. 408). Permanent magnet equipment for reparation and materials handling.

Frank G. Hough Co., Libertyville, Ill. (Booth No. 1101-1202). Tractor-shovels and attachments.

Hydro-Blast Div., American Marietta Co., Wheeling, Ill. (Booth No. 323). Dry and wet sand reclaimers, core knock-out.

Hysol Corp., Olean, N. Y. (Booth No. 1337). Epoxy tooling materials consisting of special formulated compounds for the fabrication of patterns, core boxes, matchplates, dielectric core driers and repair compounds.

Illinois Clay Products Co., Chicago. (Booth No. 1036). Fire clay, bonding clays, cupola mix, refractory castables, firebrick, shell coating mixer, cupola gun.

Indiana General Corp., see Stearns Magnetic Products Div.

Indianapolis Wire Bound Box Co., Fernwood, Miss. (Booth No. 1523). Expendable and returnable pallet boxes, miscellaneous parts boxes and bulk chemical boxes.

Inductotherm Corp., Delanco, N. J. (Booth No. 224). Integral type induction power sources, compact melting units with ferrous and non-ferrous melting furnaces.

International Automation Corp., Ann Arbor, Mich. (Booth No. 1335). Scale model of fully automated molding and pouring installation, automated pouring device.

International Foundry Supply Co., Reading, Pa. (Booth No. 1601-1605). Revecon reverbatory furnaces, fluxes.

International Graphite & Electrode Div., Speer Carbon Co., St. Marys, Pa. (Booth No. 110). Graphite electrodes for electric furnaces and molds, graphite specialties fabricated to customer specifications, granular graphities for use as carbon raisers.

International Minerals & Chemical Corp., see Eastern Clay Products Dept.

International Molding Machine Co., La-Grange Park, Ill. (Booth No. 1604). Molding and core machines, sand blowers, special equipment for foundries.

International Nickel Co., New York. (Booth No. 1404-1303). Nickel for alloying steels, cast iron, copper-base and other non-ferrous alloys. Rods for welding castings.

Iron Lung Ventilator Co., Cleveland. (Booth No. 1334). Roof ventilators and roof exhausters.

Jeffrey Mfg. Co., Columbus, Ohio. (Booth No. 1622). Foundry handling equipment, sand conditioning equipment.

Kaiser Aluminum & Chemicals Corp., see Kaiser Refractories & Chemicals Div.

Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Corp., Oakland, Calif. (Booth No. 1411). Refractories, basic materials.

Keokuk Electro-Metals Co., Div. Vanadium Corp. of America, Keokuk, Iowa. (Booth No. 1234). Silvery pig iron, silicon metal and ferroalloys for foundries and primary metal producers.

Kindt-Collins Co., Cleveland. (Booth No. 1328). Dust control equipment and accessories, patternshop equipment and supplies, woodworking machinery and accessories.

King Tester Corp., Philadelphia. (Booth No. 223). Portable Brinell hardness testing machines, standard and special attachments and related equipment.

Lester B. Knight & Associates, Inc., Chicago. (Booth No. 1403). Consulting engineers. Exhibiting model of railroad specialty foundry and cupola oxygen converter steelmaking facilities.

H. Kramer & Co., see Ajax Metal Div.
Kuhlman Electric Co., see Detroit Electric Furnace Div.

Laboratory Equipment Corp., St. Joseph, Mich. (Booth No. 39?). Hot extraction hydrogen analyzer, high frequency induction furnace, carbon and sulfer analyzers, five-min. oxygen determinators, special ceramic ware for high temperature industrial applications.

Latrobe Steel Co., Latrobe, Pa. (Booth No. 1134). Wear parts and liners for blast cleaning equipment, liners and cups for sand slinging equipment, steels for abrasion-resisting applications.

Lava Crucible Refractories Co., Pittsburgh, Pa. (Booth No. 309). Crucibles and crucible furnace refractories, crystalling heavy duty refractories, cements and grains, stopper heads, core and mold washes.

R. Lavin & Sons, Inc., Chicago (Booth No. 912). Non-ferrous metals.

E. J. Lavino & Co., see Balsam Gap Co.
Lindberg Engineering Co., Chicago. (Booth No. 1522-1524). Industrial furnaces, heat treating and melting furnaces, induction heating units.

Link-Belt Co., Chicago. (Booth No. 1428). Conveying equipment and accessories, engineering services, flexible couplings, material handling equipment and accessories, sand handling and conditioning, sand reclamation equipment, shakeout equipment and accessories, shell molding materials and equipment, vibrators.

Liquid Carbonic Div., General Dynamics Corp., Chicago. (Booth No. 1436-1438). Carbon dioxide for cores and molds, demonstration of CO_2 process.

Magnaflux Corp., Chicago. (Booth No. 624). Non-destructive testing systems including magnetic particle, fluorescent and dye penetrant, ultrasonic and eddy current. Brittle coatings for stress analysis.

Magnet Cove Barium Corp., Arlington Heights, Ill. (Booth No. 438). Foundry research underway at new research and development center, bentonite bonding agents for foundry sands.

Main Bros. Box & Lumber Co., Karnak, Ill. (Booth No. 507). Wooden wirebound

pallet boxes for castings, ferro alloys, ores, composite wirebound containers for regulated and non-regulated liquids, industrial shipping containers.

Manganese Steel Forge Co., Philadelphia. (Booth No. 213). Rolled manganese steel wear parts, including molding machine rails, hopper liners and shot blast wear parts.

Manley Sand Co., Rockton, Ill. (Booth No. 626). Industrial sands for molding and coremaking.

Martin Engineering Co., Neponset, Ill. (Booth No. 116). Vibration inducers and accessories, full line of core box protection items.

Massey-Ferguson, Inc., Wichita, Kans. (Booth No. 208). Industrial tractors with loader and backhoe, also demonstration of instant reverse in above tractors.

Master Power Co., Bedford, Ohio. (Booth No. 904-906). Portable air tools, air hoists, air saws.

Metallizing Co. of America, Inc., Chicago. (Booth No. 1238). Model vacuum-pressure impregnating unit, impregnating compound, welding equipment for salvaging castings, combination unit for spraying powder metal and ceramic deposits.

Metallurgical Products Co., Philadelphia. (Booth No. 333). Metal alloys. Phosphor copper, manganese copper, aluminum copper, copper shot, copper-nickel shot copper and brass anodes, secondary metals and alloys.

Mexico Refractories Co. Div., Kaiser Aluminum & Chemical Sales, Inc., Mexico, Mo. (Booth No. 1411). See Kaiser Refractories & Chemicals Div.

Milwaukee Chaplet & Mfg. Co., Milwaukee. (Booth No. 327). Chaplets, chills, mold anchors, core bolts, threaded stem, double head and motor chaplets, radiator and perforated chaplets, adjustable and standard radius chills, shift-eliminating mold anchors.

Minerals & Chemicals Corp. of America, Menlo Park, N. J. (Booth No. 1418). Binder for green sands using an oil system, suspending agent in water and solvent base core and mold washes.

Mine Safety Appliances Co., Pittsburgh, Pa. (Booth No. 202). Safety clothing and equipment.

Modern Equipment Co., Port Washington, Wis. (Booth No. 1409). Colored translites to show applications for water-cooled cupolas, hot-blast heaters and pouring devices.

Jesse S. Morie & Son, Inc., see Daniel Goff Co.

The Moulders' Friend, Dallas City, Ill. (Booth No. 1542-1543). Sand handling and conditioning equipment and accessories.

Murrell Dobbins Technical School, Philadelphia. (Booth No. 1635-1637-1639). Foundry student training group, 20 students will do green sand jobbing-molding and production molding on a jolt-squeeze machine. Working exhibit will comprise area of 15x62 ft.

Nassau Smelting & Refining Co. Inc., Tottenville, N. Y. (Booth No. 1624). Brass and bronze ingots, billets and casting copper.

National Acme Co., see Shalco Div.

National Carbon Co., Div., Union Carbide Corp., New York. (Booth No. 1214-1218-1220). Carbon and graphite for melting and handling metals, including molds, crucibles, cupola linings, brick, arc furnaces, electrodes, cores and chills, fluxing tubes and powders. Also brushes, spectroscopic electrodes, nuclear graphite and graphite textiles.

National Crucible Co., Philadelphia. (Booth No. 220). Carbon-bonded crucibles, furnace linings, base blocks, refractory cements and induction furnace refractories.

National Engineering Co., Chicago. (Booth No. 1114-1118-1120-1122-1015-1019-1021-1023). Batch mullers, continuous mullers, shell mullers, sand scrubbers, coolers and conveyors.

National Glass Sand Corp., Millville, N. J. (Booth No. 108). Display samples of industrial sands and sand-blasting sands.

National Lead Co., see Baroid Chemical Co. Div.

National Metal Abrasive Co., Cleveland. (Booth No. 528). Blastcleaning media.

National Pigment Co., Philadelphia. (Booth No. 1424). Riser and hot top compounds, fully and partially exothermic compounds, fluxes.

Newaygo Engineering Co., Newaygo, Mich. (Booth No. 1507-1509-1511-1606-1608-1610). An operating display of pallet system of mold handling with special components as a traveling pallet car dump, stationary dump, power-operated car lift for molders; high-capacity sand handling system and control system for automatic filling of sand hoppers.

New England Coke Co., Boston. (Booth No. 1133). Coke.

New Jersey Silica Sand Co., Millville, N. J. (Booth No. 216). Washed and graded silica sands, moisture-controlled molding sands and gravels, high-bond sands, sandblast sands, silica flour.

Nomad Equipment Corp., Milwaukee. (Booth No. 1137-1139). Track type mold conveying systems with pallets and bottom boards, mold dumps, pallet raisers and a tight flask shakeout punchout unit.

North American Smelting Co., Wilmington, Dela. (Booth No. 313). Brass and bronze foundry alloys, aluminum for die and permanent mold casting, aluminum for deoxidizing and other destructive purposes, zinc alloys for diecasting, lead and zinc for use as additives. Phosphor copper waffle and shot, hardeners, pattern metals, babbitts, solders, type metals.

Northwest Olivine Co., Seattle. (Booth No. 1237). Olivine sand.

S. Obermayer Co., Chicago. (Booth No. 1329). Core and mold coatings, flask clamps, refractories, shell coremaking machines.

Ohio Electric Mfg. Co., see Homer Mfg. Div.

Ohio Ferro Alloys Corp., Canton, Ohio. (Booth No. 1034). Ferro-alloys for gray iron, malleable iron, steel, ductile iron and aluminum castings, ferro alloys of silicon, manganese, chromium, magnesium; ferro-alloy briquets, exothermic ferro-alloys, mischmetal and rare earth alloys.

Olin Mathieson Chemical Corp., New York. (Booth No. 1022-1024). CO_2 equipment and supplies, non-ferrous ingots.

Oliver Machinery Co., Grand Rapids, Mich. (Booth No. 1508-1510). Patternshop equipment.

Orefraction Minerals, Inc., Andrews, S. C. (Booth No. 217). Domestic zircon sand and zircon flour in 140-200-325-400 mesh sizes.

Osborn Mfg. Co., Cleveland. (Booth No. 1115-1119-1121). Blow-squeeze molding machines, jolt squeeze, jolt squeeze stripper, rollover molding machines, automatic mold and flask equipment, core blowers and foundry equipment accessories and vibrators.

Pangborn Corp., Hagerstown, Md. (Booth No. 1203-1207-1209-1211-1304-1306-1308-1310). A complete line of cleaning barrels including 32 cu ft, 20 cu ft and 15 cu ft; heavy duty machines and 12 cu ft, 6 cu ft and 3 cu ft standard machines. Also the new 6 cu ft vibratory finishing machine, new cloth bag dust collector, wet dust collector, unit type dust collector, wear plates and steel shot and grit.

Pekay Machine & Engineering Co., Chicago. (Booth No. 1123). Continuous sand conditioners for small and large foundries; sand systems; self-cleaning elevator buckets; shakeout sand cooling; tempered sand cooling.

Albert W. Pendergast Safety Equipment Co., Philadelphia. (Booth No. 407). Goggle cleaning and anti-fogging stations, new metatarsal guard, safety equipment and apparel for foundry and other industrial uses.

Penn-Rillton Co., New York. (Booth No. 320-417). Foundry facings, core compounds, wood flour.

Pennsylvania Foundry Supply & Sand Co., Philadelphia. (Booth No. 301). Chaplets and chills, cupola lining gun, sprue cutters, resin coated sands, CO_2 binders.

Pennsylvania Glass Sand Corp., Pittsburgh, Pa. (Booth No. 430). Silica products for foundry use, silica molding and core sands, sandblast abrasives, bonded sand, silica gravel, silica flour.

Penola Oil Co., Detroit. (Booth No. 623). Core oils, air-setting binders, dielectric curing oil-type binder, carbon sand, oil-sand preservative.

Penton Publishing Co., Cleveland. (Booth No. 1104). Foundry magazine.

Pettibone-Mulliken Corp., see Beardsley & Piper Div.

George F. Pettinos, Inc., Philadelphia. (Booth No. 728-730-825). Core, mold, blasting sands, graphite and non-graphite mold and core washes and facings, binders, core paste, clays, southern and western bentonite, wood flour, parting, metal abrasives, cupola patching materials, supplies.

Philadelphia Coke Div., Eastern Gas & Fuel Associates, Philadelphia. (Booth No. 1133). Foundry and metallurgical coke.

Picker X-Ray Corp., White Plains, N. Y. (Booth No. 721). Stationary magnetic testing machine and mobile magnetic testing machine for foundry applications, portable 200 Kv x-ray machine, iridium and cobalt isotope handling equipment.

Pittsburgh Crushed Steel Co., Pittsburgh, Pa. (Booth No. 1503). Shot and grit.

Planet Corp., Lansing, Mich. (Booth No. 1129). Mechanized foundry systems.

Presstite Div., American Marietta Co., St. Louis. (Booth No. 323). Sealing compounds.

Pressure Match Plate Co., Inc., Philadelphia. (Booth No. 310). Pressure cast aluminum products from plaster molds, matchplates, cope and drag plates, core boxes, precision pattern castings, molds for rubber and plastic industries.

Punch-Lok Co., Chicago. (Booth No. 336). Hose clamps, fittings and tools for their application.

Pure Carbonic Co. Div., Air Reduction Co., New York. (Booth No. 1233). Welding equipment and supplies, CO_2 equipment and supplies.

Pyrometer Instrument Co., Bergenfield, N. J. (Booth No. 1309). Pyro-optical, surface, immersion, indicating, micro-optical and radiation pyrometers and pyrometer accessories. Double-range, dual-purpose surface and immersion pyrometer and optical pyrometer calibrating set.

Redford Iron & Equipment Co., Detroit. (Booth No. 1125). Core and mold blowing equipment.

Roessing Bronze Co., Pittsburgh, Pa. (Booth No. 505). Brass, bronze and aluminum ingots, deoxidizing aluminum.

Ross-Tacony Crucible Co., Philadelphia. (Booth No. 1038). Clay bonded and carbon bonded crucibles and refractories, graphite stopper heads.

Royer Foundry & Machine Co., Kingston, Pa. (Booth No. 1001-1102). Working exhibit in conjunction with Clearfield Machine Co. A Royer scrap control feeding a skip hoist and muller, discharging into aerator.

George Sall Metals Co., Philadelphia. (Booth No. 1423). Non-ferrous ingots, aluminum, brass and bronze alloys; casting data and information.

Claude B. Schneible Co., Detroit. (Booth No. 1224). Dust collectors, cupola fly ash collectors, adjustable pouring hoods, shake-out hoods, scrubbing equipment for cupola fly ash.

Schramm, Inc., West Chester, Pa. (Booth No. 924-926). Stationary air compressors with components and accessories in operation; also supplying air for other exhibitors.

Scientific Cast Products Corp., Cleveland. (Booth No. 427). Pressure cast matchplates, cope and drag plates, core boxes, drier patterns, precision prototype castings, vacuum forming molds.

Security Alloys Co., Chicago. (Booth No. 324). Pre-alloyed furnace charges for stainless steel and nickel alloy foundries.

Semet Solvay Div., Allied Chemical Corp., New York. (Booth No. 615). Coke.

Servo Lift, Chicago. (Booth No. 206). One-handed "load leading" control handle for an air-operated variable speed materials handling unit suspended from a standard trolley on a swinging jib crane.

Shalco Div., National Acme Co., Cleveland. (Booth No. 1302-1400-1402-1401). Complete line of shell core blowers, shell molding machines, shell sand coating machines.

Shaw Process Development Corp., Port Washington, N. Y. (Booth No. 306). Massive precision castings in the aircraft, missile, pump and impeller and tool and die fields.

Shell Process, Inc., West Springfield, Mass. (Booth No. 1629-1631). Automatic shell molding and shell core machines, sand drying tanks, bonding presses, bucket elevators and shell molding pattern accessories.

Simplicity Engineering Co., Durand, Mich. (Booth No. 1143). Feeders for transferring sand or castings, shakeout with magnetic head, pulley and belt.

Sipi Metals Corp., Chicago. (Booth No. 1307). Brass and bronze ingot, lithium deoxidizers, aluminum, copper shot, die casting alloys, slab zinc, zinc dust, zinc oxide.

O. E. Smith, Inc., Pittsburgh, Pa. (Booth No. 2228). Air setting binders and facings; zircon washes, sand and flour; light-off washes; exothermic compounds; waterless hand cleaner.

Smith & Richardson Mfg. Co., Geneva, Ill. (Booth No. 1008). Chaplet display boards with castings showing use of chaplets.

Speer Carbon Co., see International Graphite & Electrode Div.

SPO, Inc., Cleveland. (Booth No. 1028-1032-929-933). Molding machines, shell core machines.

Stahl Specialty Co., Kingsville, Mo. (Booth No. 305). Permanent mold operating equipment.

Standard Electrical Tool Co., Cincinnati. (Booth No. 230). Single and double-end infinitely variable speed snagging grinders with dust collectors.

Standard Horse Nail Corp., New Brighton, Pa. (Booth No. 520). Solid foundry chill nails and spider chills, machine keys, woodruff keys, taper pins, straight pins, cotter pins and special parts.

Stearns Magnetic Products Div., Indiana General Corp., Milwaukee. (Booth No. 209). Permanent magnet pulleys and other magnetic separation equipment for foundry applications.

Sterling National Industries, Inc., Milwaukee. (Booth No. 1420). Rolled steel foundry flasks, extra heavy duty flasks, pouring jackets, aluminum squeeze-in bottom boards, flask pins and bushings.

Frederic B. Stevens, Inc., Detroit. (Booth No. 1014). Liquid parting, CO_2 binder, core washes, core pastes and other foundry facings; sand muller.

F. J. Stokes Corp., Philadelphia. (Booth No. 338-435). Precision casting vacuum furnace capable of pouring 17 lb (steel) under vacuum in range of 1-5 microns.

Sutter Products Co., Holly, Mich. (Booth No. 1537-1539-1636-1638). Shell cores and shell molding machines.

Tabor Mfg. Co., Div. Turbo Machine Co., Lansdale, Pa. (Booth No. 1613). Foundry molding machines, abrasive cutoff machines, dust collectors.

Taccone Corp., North East, Pa. (Booth No. 1501). C-frame diaphragm molding machine and match plate mold machine with vacuum pattern holding features.

Taggart Brimfield Co., Hammonton, N. J. (Booth No. 207). Foundry sands and gravels.

Thor Power Tool Co., Aurora, Ill. (Booth No. 1311). Air grinders and hammers, high frequency (360 cycle) electric grinders; air hoists; complete line of portable air and electric tools; air marking pen.

Toledo Scale Corp., see Toledo Scale Div.

Toledo Scale Div., Toledo Scale Corp., Toledo, Ohio. (Booth No. 1425). New variable counting scale, vernier and digital batching demonstrators, remote weight data recorder.

Turbo Machine Co., see Tabor Mfg. Co. Div.

Union Carbide Corp., see Union Carbide Metals Co. Div. and National Carbon Co.

Union Carbide Metals Co., Div., Union Carbide Corp., New York. (Booth No. 1214-1218-1220). Ferroalloys and metals for cast iron, ductile iron, steel and aluminum.

United Oil Mfg. Co., Erie, Pa. (Booth No. 1325). Core binders including conventional core oils, resin type binders, binders in emulsion form, bonding agents for shell molding, an air drying wash for cores and molds, an air drying spray for building surface hardness with a resin bond, release agents and liquid parting.

United States Gypsum Co., Chicago. (Booth No. 815). Epoxy patternmaking plastics, plaster and gypsum cements; plastic faced gypsum plaster metal casting plasters for precision castings.

Valvair Corp., Akron, Ohio. (Booth No. 1107). Solenoid and manually operated air control valves, poppet-type solenoid operative control valves, manifolds, mill-type and heavy-duty air cylinder, air line filters, regulators and lubricators.

Vanadium Corp. of America, see Keokuk Electro-Metals Co.

Vesuvius Crucible Co., Swissvale, Pa. (Booth No. 1315). Graphite refractories, stopper heads, crucibles.

Walker Pneumpac Machine Mfg. Div., Walker Pump Co., Brooklyn, N. Y. (Booth No. 1336). Airless blast cleaning equipment, steel shot and grit.

Walker Pump Co., see Walker Peenimpac Machine Mfg. Div.

Westinghouse Electric Corp., X-Ray Dept., Baltimore, Md. (Booth No. 531). Lightweight industrial x-ray units from 140 KVP, 1-¾ in. of steel, to 300 KVP, 4 in. of steel. Industrial Cobalt 60 unit for gamma radiography up to 7-½ in. of steel.

Wheelabrator Corp., Mishawaka, Ind. (Booth No. 1342-1442). Airless blast equipment, high efficiency abrasive separators, steel shot, wear plates and electric furnace fume collector systems.

Whirl-Air-Flow Corp., Minneapolis. (Booth No. 1514). Pneumatic conveyors, pneumatic chip injectors.

Whitehead Bros., Co., New York. (Booth No. 316-413). Abrasives and clay, CO_2 equipment and supplies, core and mold washes, core binders, facings, foundry supplies, mold and core washes, sand, shell molding materials and equipment.

Wolverine Foundry Supply Co., Detroit. (Booth No. 535). Shell cores, coated sand for shell process.

Yale & Towne Mfg. Co., Philadelphia. (Booth No. 416-420-422-424-426-513-517-519-521-523). Gasoline industrial tractor shovels; gas, electric and hand industrial lift trucks; air, electric and hand hoists; hand and motorized trolleys.



Plant Visitations

Foundries in a three-state area will be open to visitors at the AFS Castings Congress & Exposition. A variety of 14 metalcasting plants will assure foundrymen of a wide choice of sizes, production techniques and processes.

Casting sizes range from 1 oz to 75,000 lb, daily production from 1 to 100 tons and metals poured include gray and malleable iron, carbon and alloy steel, brass, bronze and nickel alloys.

To help you select the foundries meeting your specific interests, the following guide details the operations and gives location and hours open to visitors.

ALAN WOOD STEEL CO., Conshohocken, Pa. (Thurs.).

An integrated steel mill with facilities for producing pig iron, fabricated carbon steel products, alloy steels, coke and chemicals.

ATLANTIC STEEL CASTING CO., Sixth & Lloyd Sts., Chester, Pa., (Mon.-Fri. . . . 10 am-5 pm).

A 180-man jobbing shop making low alloy, carbon steel castings weighing 2-16,000 lb. Melt with acid electric furnace. Pour 20 tons daily. Mold with sand slingers and practice dry stack molding. Coremaking uses sand blowers, air-set binders and dielectric oven baking. Special techniques involve powder washing, submerged arc welding and low hydrogen iron powder rod.

BIRDSBORO CORP., Birdsboro, Pa., (Mon.-Fri. . . . 8 am-5 pm).

A 600-man jobbing, production and captive shop. Make carbon and alloy steel castings weighing 25-75,000 lb for rolling mills, hydraulic presses, jaw-type crushers, marine, ordnance, hydraulic and steam turbines, freight car trucks, miscellaneous jobbing castings and steel rolls. Melt with basic electric arc furnaces pouring 15-20 tons daily. Molding methods include cement, skin-dried green sand, green sand and dry sand. Cores are hand rammed and blown in sand and dry sand.

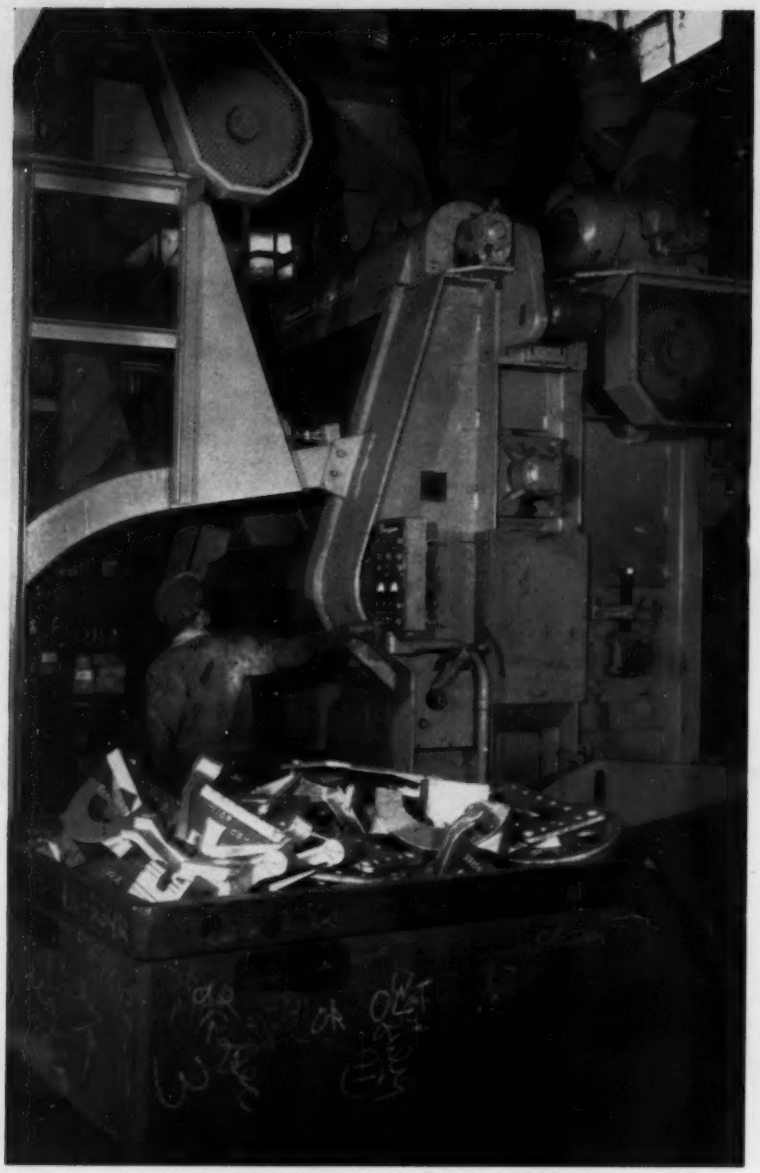
Produces malleable iron and converter steel castings. Melting equipment includes one cupola rated at 6 tons per hr; three air furnaces, one with 16 tons capacity per charge and two with 32 tons capacity per charge; two converters hold 2 tons per charge.

H. G. ENDERLEIN CO., Keystone & Benner Sts., Philadelphia (Mon.-Thurs.).

A 75-man jobbing shop making gray iron (Class 30-50) low alloy castings weighing 1-10,000 lb including counterweights for front end loaders, paper and paper box machinery. Melt with cupola lined to 42 in. Pour 20-30 tons per 8-hr shift. Molding methods include squeezer, jolt-roll-over, jolt-rollover-pin lift and hand ramming. Cores are all hand rammed. Large cores made by air-set process.

FLORENCE PIPE FOUNDRY & MACHINE CO., Front St., Burlington, N.J., (Time and date to be announced).

A 1200-man captive, production jobbing shop producing gray iron products including centrifugally cast iron pipe (sand spun), static machinery castings and valves and hydrants ranging from 1/4-lb to 10 tons. Melt with cupolas producing 300 tons per



8-hr shift. Mold by jolting and sand slinger. Cores are air-rammed. Special features: water-cooled cupolas complete with hot-blast and skip charger; also complete sand handling including cooling sand from 550 F to 100 F before entering fully automatic controlled mixing.

LEHIGH FOUNDRIES CO., 1500 Lehigh Drive, Easton, Pa., (Mon.-Fri. . . . 24 hours daily).

A 275-man malleable and gray iron jobbing foundry making a wide range of castings weighing from 1/4 to 110 lb. Melting equipment: electric arc furnaces pouring 25 tons daily. Mold green sand by machines. CO_2 coremaking. Castings are annealed in a 28-hr cycle in furnace built by Lehigh Foundries.

LINK-BELT CO., OLNEY FOUNDRY, 180 Duncannon Ave., Philadelphia (Tues.-Thurs.-Fri.).

A 220-man captive jobbing shop making gray iron, chilled iron and alloy iron machinery and engineering castings weighing 1-15,000 lb. Melting is by cupola with 8-hr production of 30-50 tons. Molding methods: jolt-squeze, jolt-pin-lift, jolt rollover, sand slinger and hand ram.

NORTHERN BRONZE CORP., Torresdale Ave. & Womrath St., Philadelphia (Mon.-Fri. . . . 8 am-4 pm).

A 30-man job shop making brass, bronze and nickel alloy castings weighing 1-800 lb. Melt in coke-fired crucible furnaces, pouring 2000 lb per 8-hr shift. Bench, floor and machine molding. CO_2 core and mold making.

TEXTILE MACHINE WORKS, FOUNDRY DIV., Reading, Pa. (Mon.-Fri. . . . 8 am-4 pm).

A 500-man captive jobbing and production shop making gray iron, semi-steels, ductile, Ni-Resist, aluminum and bronze castings with ferrous castings ranging from 1 oz to 5000 lb and non-ferrous from 1 oz to 1000 lb. Melting equipment: hot and cold blast cupolas; electric and gas furnaces for ferrous; gas and coke for non-ferrous. Pour 100 tons of ferrous castings per 8-hr shift and 5 tons for non-ferrous.

UNITED STATES PIPE & FOUNDRY CO., Burlington, N. J. (Tues., Thurs.).

Plant produces cast iron pressure pipe and fittings, tubular products of gray and alloy iron, carbon and alloy, stainless steels, iron and coke. Extensive melting equipment includes two cupolas, a 12,000 lb arc furnace, eight induction furnaces—six of 1000 lb, one of 2000 lb and 1 of 24,000 lb capacity.

UNIVERSAL RUNDLE, CORP., Camden, N. J. (date to be annonuced).

Produces gray iron plumbing fixtures in shop operating two cupolas rated at 23 tons per hr.

WELSBACH CORP., KITSON VALVE DIV., Westmoreland & Stokley Sts., Philadelphia (Mon.-Fri. . . . 9 am-3 pm).

A 35-man captive foundry pouring red brass castings for ground key cocks, drainage fittings weighing from 1 oz to 15 lb. Melting equipment: oil-fired crucible-type furnaces. Pour 15,000 lb in 8-hr day. Molding methods: jolt-squeeze machines using steel flask and cope and drag plates. Coremaking: oil sand cores both blown and hand-rammed. Special interest: using synthetic molding sand with overhead equipment.

WILKENING MFG. CO., 2000 S. 71st St., Philadelphia (Mon.-Tues.-Thurs.-Fri. . . . 9:30 am-12 noon, 1:30 pm-3 pm).

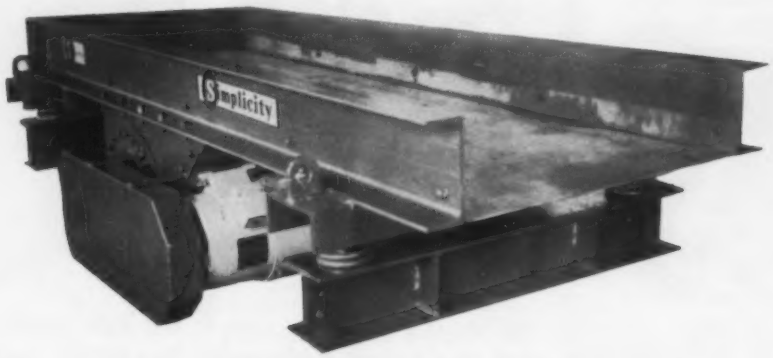
A 75-man captive shop making cast iron piston rings weighing from 15 lb to 25 lb each. Melt in 36-in. cupola, pouring 20 tons per 8-hr shift. Special technique: stack molding.

Exhibitors' Products Preview . . .

May 9-13 promises to be one of the most important weeks in the future of the metalcasting industry . . . Philadelphia will be the location and the AFS Exposition is the big event. The Exposition offers the only opportunity within the next two years for foundrymen to see and evaluate the latest in foundry equipment and processes on an industry-wide basis. Here are some of the products you will see:

Special Conveyor Pan Construction Allows Handling of Hot Materials

Conveyors for handling hot materials will be shown at the Castings Exposition by Simplicity Engineering Co., Durand, Mich. Special pan construction permits handling of 1400 F material without burning or warping the conveyor sections. Damp material can be dried by passing hot air over the material surface or by the direct application of heat as the material vibrates along the steel pan surface. Cold air can be similarly used for cooling sand and castings.



Airless Blast Cleaner

Airless blast cleaner features low initial cost as well as nominal maintenance and operating costs. New to the foundry field, it has been used in the automotive rebuilding field where dirt, grease and rust must be removed from metals and plastics. Unit uses the peening process. At the Castings Exposition, see the 7-cu ft model by Walker Peenimpac Machine Mfg. Div., Walker Pump Co., Brooklyn, N. Y.



All Shifts on Tractor Shovel Can Be Made While Unit Is Moving

New tractor-shovel with 3000-lb operating capacity has three speed ranges in each direction. All shifts can be made on the go with no need to stop for range shifts. Single long-stroke hydraulic ram with high-leverage linkage to the bucket develops powerful bucket breakout action for tough digging assignments. Both fuel tank and transmission can be checked and filled from ground level. See this machine at the display of Frank G. Hough Co., Libertyville, Ill.



Continued on page 72

Products Preview

Continued from page 71

Coreshooter—CO_2 Gasser

A combined automatic coreshooter and CO_2 gasser with a three-station turntable designed to shoot, gas and strip cores on a 5 to 8- second cycle will be demonstrated at the Exposition by Hansberg Shooters, Inc., Evanston, Ill.

The unit is available with turntable diameter of either 24 or 42 in. for production of cores weighing up to 5 or 8-1/2 lb. The fully automatic machine produces cores continuously. As the operator is removing one core, a second is being shot and a third is being gassed. The rotary table is equipped with three clamping fixtures to which the side portions of vertically divided core boxes are fixed. These side parts are withdrawn automatically.



Foundry Services Demonstrates Two Aids for Castings at Exposition

A metal pouring demonstration using two new casting aids will be conducted by Foundry Services, Inc., at the AFS Exposition. A tilt-type electric melting furnace will show the use of Feedex and Logas 40 in feeding castings and degassing metal.

Feedex is a moldable exothermic used with iron, steel, copper-base alloys and aluminum and magnesium alloys. When mixed with water, it can be molded into any required shape. Molten metal entering the riser ignites the material which burns at a uniform rate.

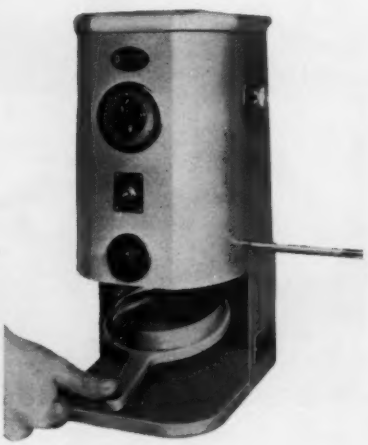
Logas 50 is a solid compacted briquette developed to eliminate gas porosity in copper and copper-base castings. The briquette is plunged beneath the molten metal surface to release a stream of scavenging gases.



Low-Cost Moisture Tester Eliminates Chemicals and Special Calibrations

A new low-cost moisture tester for foundry sands will be shown by the Harry W. Dietert Co., Detroit, at the AFS Exposition. The unit is designed primarily for intermittent duty where fast drying is important. It reportedly reaches a preset drying temperature faster than any similar unit in its field.

The combination of fast heating and high static pressure from a high-speed blower represents an important step toward faster moisture determination.



Plastic-Faced Plaster Technique Combines Both Speed, Low Costs

Plastics for patternmaking will be stressed at the Castings Exposition by U. S. Gypsum Co., Chicago. Among the demonstrations will be the plastic-faced plaster technique for making molds for patterns or core sticks for plastic core boxes. This low-cost mold has epoxy plastic face and an inexpensive plaster back-up. Spray techniques are used for applying plastic.



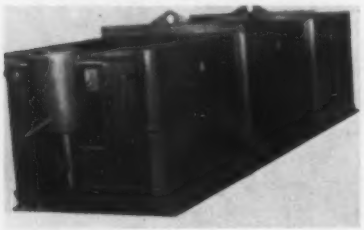
Wet Water Applications Cut Mulling Time Without Losing Flowability

Portable wet water mixer, powered by plant water pressure, which automatically proportions especially formulated multiphase surfactants, will be demonstrated at the Castings Exposition by Deynor Corp., Mamaroneck, N.Y. Surfactants reduce both mulling time and moisture content of molding sands without loss of flowability. They may also be used for improving shakeout characteristics, cupola relining and general dust control in the foundry.



Centrifugal Casting Unit Produces Long Lengths In Variety of Metals

Horizontal centrifugal casting machine produces castings weighing up to 30,000 lb and up to 20 ft long. Machines include jet water-cooling, gas mold heating and electronically variable speed drive. A car-type, semi-automatic spray lance system for spraying molds may be supplied as an accessory. Used for production of long length tubular castings of stainless steel, steel, iron and bronze used in heat-treating furnaces, chemical plants, refineries, steel works and industrial plants. For details, see the Centrifugal Casting Machine Co. display at the AFS Exposition.



New Binder Conditions Cores, Molds While Eliminating Baking Operations

A new binder which conditions sand molds and cores without baking, recently introduced by G. E. Smith, Inc., Pittsburgh, Pa., will be exhibited at the AFS Exposition. It is recommended for production, semi-production and jobbing work for iron, steel and non-ferrous casting.

In molding and coremaking, the binder is used essentially the same as conventional binders except that no ramming is required. In place of baking from two to ten hours, cores and molds are air-dried for four to ten hours, depending upon the casting size. Complete collapsibility during shakeout is reportedly assured.

Plastic Rubber Parts Resist Wear, Reactions of Chemicals and Impact

Greatly increased life in foundry applications involving abrasion, erosion, impact and chemical reactions are claimed for Abra-Shun and Ero-Shun, plastic rubbers developed by Dike-O-Seal, Inc., Chicago. Available as blow tubes and plugs; wear pads, feeder, riser and pouring basin formers; blow pads opposite blow tubes either vented or solid; loose pieces; core box liners; replacements for steel facings on flasks. See exhibit at Castings Exposition.



Molding Systems Bring Mechanization to Any Plant Layout

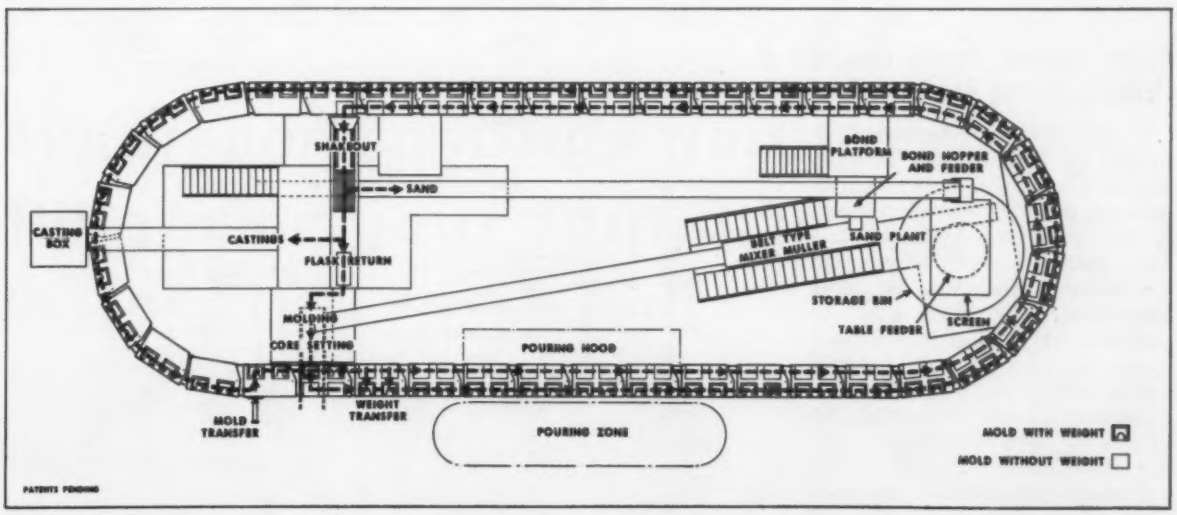
Three molding systems—a continuous loop design, an indexing type and the third providing unlimited flexibility—will be emphasizer at the C. O. Bartlett & Snow Co. exhibit at the AFS Exposition.

In the continuous loop design, molds are carried side by side. Starting in an outside position on the car, molds are transferred automatically to an inside position. They continue around the loop a second time and are removed automatically at shakeout. The system is suited for handling any type of mold or metal. Molds can be set out, closed and poured while the conveyor is in motion.

An indexing type system is recommended with large, heavy, flasks which cannot be located on the conveyor, poured and removed while the conveyor is in motion. This system employs a rectangular loop consisting of two straight runs connected with a rotary turn at one end and transfer car at other end.

In the third system the entire pallet of 18-20 molds—or more—is loaded onto a transfer car and delivered to the pouring area. Handling similar molds together in groups permits molds of different sizes, for different castings, to be handled economically.

Continued on page 74



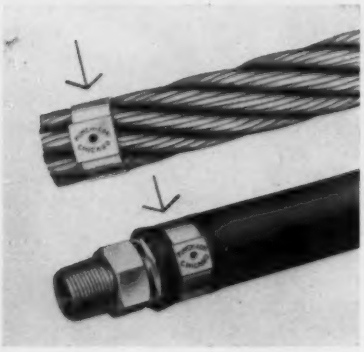
Products Preview

Continued from page 73

Lightweight Hose Clamp Eliminates Fitting Slippage Under Pressure

A lightweight hose clamp, claimed to prevent slippage of hose fittings under pressure on foundry maintenance hose will be displayed and demonstrated at the Castings Exposition by Punch-Lok Co., Chicago, a new exhibitor at the Exposition.

With no bolts, screws or other projections to catch or snag, the Punch-Lok hose clamp consists of a broad flat band of high-tensile steel, double-wrapped around the hose. After tensioning with a hand locking tool, the excess metal band is then broken off clean. The clamps are easy to put on and make leakproof connections that last the life of the hose.



Dip-Out Furnaces Provide Low-Cost Method of Melting Aluminum, Brass

Reverbale dip-out furnaces engineered by International Foundry Supply Co., Reading, Pa., and capable of handling 300-900 lb hourly, are said to cut aluminum and brass melting costs by 66 per cent for permanent mold and diecasting operations. These furnaces will be operating at the Castings Exposition.

Fast production of castings with a maximum 1 per cent metal loss is possible with either gas or oil. Reverbale furnace is built on the dry hearth principle and equipped with two burners. One melts the metal, the other holds the metal bath at the required temperature. Advantages include: no separate melting section; no chilling of metal when adding fresh ingots.



Gunning Cupola Refractories

Cupola refractories may be gunned directly onto the cupola shell in less than half the time it takes to install cupola block. This method of lining the charging zone and upper stack area of the cupola offers savings through lower installation costs, lower materials costs, less cupola down-time plus increasing lining life. Refractory dries rock hard—ready for use in 24 hr. Designed for 2400, 2700 and 3000 F. Illinois Clay Products Co., Chicago, will have cupola castables on display as well as a film of the gunning of the cupola stack.

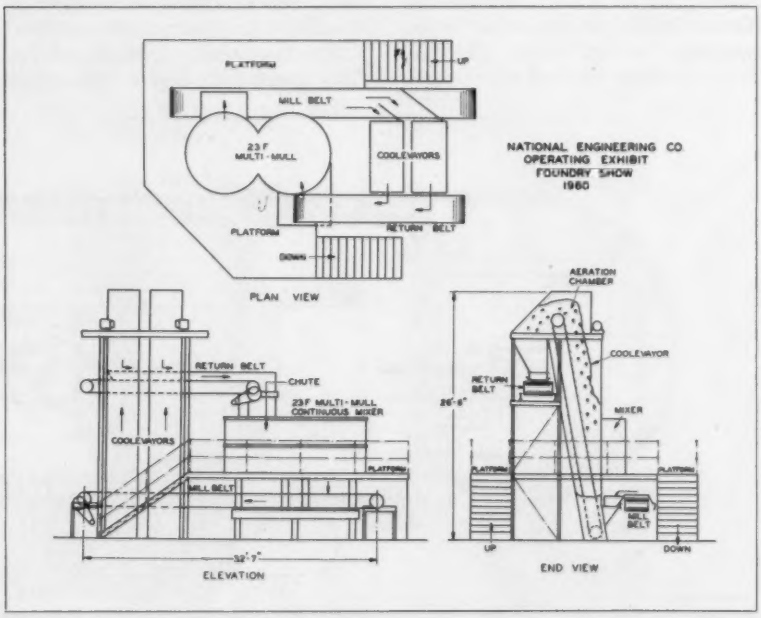
Exhibit Demonstrates Continuous Sand Conditioning Systems

National Engineering Co., Chicago, will exhibit two new items of equipment in a full-scale operating sand conditioning system at the Castings Exposition.

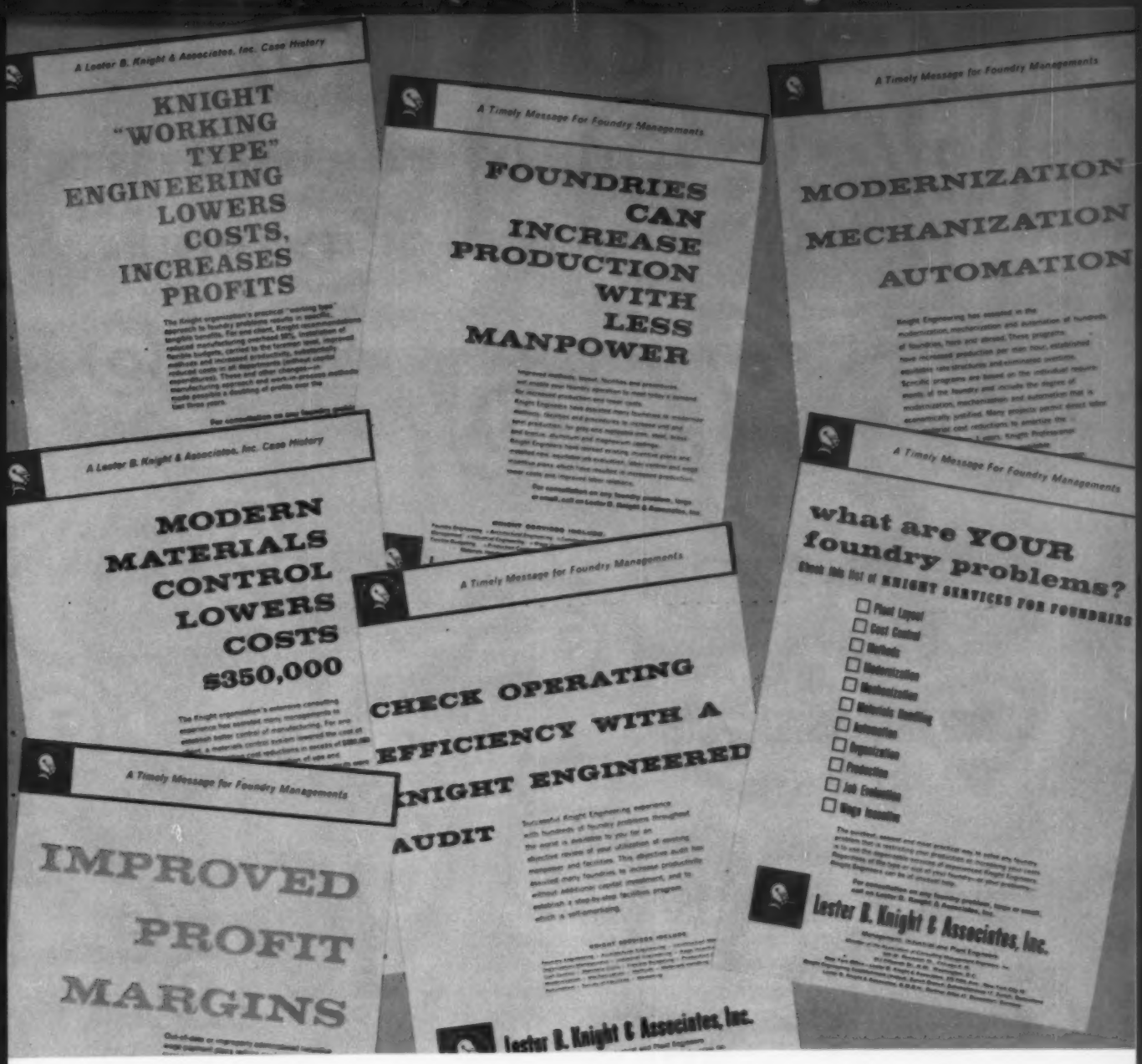
Featured will be a Simpson Multi-Mull, a continuous muller, arranged to discharge continuously to a mill belt serving two National Coolevayors. The cooling equipment is designed to elevate, aerate and cool the sand from temperatures 200 F or more to within 20 F of room temperature, before discharge to a return belt which recharges the continuous muller. The system is rated at 180 tons per hr. Cooling will be simulated.

According to National, the exhibit will demonstrate the quality and high quantity of sand which can be handled with a continuous muller and how system sands can be cooled on a continuous basis and how the Coolevayor can be integrated to serve a dual cooling and elevating role.

In addition to the operating exhibit, National will announce the results of their $5000 contest-search for the oldest Simpson Mix-Muller still operating in a foundry.



Circle No. 207, Page 207



Whatever castings you produce...
Whatever your foundry problem...



call on Knight engineering

for increased production and

Here is the wide scope of Knight services utilized in the successful completion of foundry assignments ranging from the solution of a single problem in one department to the layout, design and supervision of construction of complete new plants.

FOUNDRY ENGINEERING Complete surveys of plants to establish the basic requirements for modern, low-cost operation. Knight Engineers become, temporarily, a part of the client's organization to make a comprehensive, objective analysis and, with the client's staff, develop the most modern methods and facilities. The result always is a better solution than either group could develop separately.

ARCHITECTURAL ENGINEERING Undivided responsibility, from drawing board to completed plant, has insured savings in time and money. Knight experience has helped to improve working conditions in a simple, functional plant designed for foundry operation. Knight has a complete and experienced mechanical, electrical, structural and architectural staff who have supervised the design of hundreds of millions of dollars of industrial plants.

CONSTRUCTION MANAGEMENT After plans have been approved, Knight has acted as the client's representative to supervise construction at minimum cost. This has included supervision of "cost-plus" as well as fixed price contracts. The saving in time and money is far greater than the cost of complete construction management service.

FOUNDRY MODERNIZATION Modern methods, facilities, controls, rigging and operating techniques can and must be used by all foundries to insure low cost, profitable operations with high take home pay, low unit costs and adequate return.

FOUNDRY MECHANIZATION The degree and type of mechanization should be established for each requirement. The simplest unit of rugged design and construction to insure minimum maintenance is a must. Over-mechanization should be avoided.

MATERIALS HANDLING By proper plant layout and handling methods, manual handling has been reduced to a minimum. The ideal, of course, is to perform an operation on the material each time it is handled. In the foundry from 100 to 400 tons of material are handled to ship 1 ton of castings.

AUTOMATION Automation can and must be applied in foundries to the degree justified by the particular problem. Knight engineered the first fully automated unit producing 272 molds per hour, 16 hours per day. Many other operations have been established on semi and fully automated cycles. Each problem is a study in itself to establish its economic justification.

experience
lower unit cost



SURVEYS Knight-engineered audits of operations can assist you to establish the changes necessary to secure maximum utilization of facilities and manpower—and thus maintain the most efficient, low-cost operation.

MARKETING Knight has surveyed markets to establish the availability of work suitable for a particular foundry and the type of facilities to be established.

FOUNDRY MANAGEMENT Knight has reorganized, refinanced and operated foundry businesses successfully and temporarily directed operations in one or more departments for short periods to establish low cost operations.

FOUNDRY ORGANIZATION Knight has established simple organization programs pinpointing responsibility and authority, providing proper communication between various functions and providing complete administrative and procedure manuals to make certain that all are familiar with policies and each understands his job.

INDUSTRIAL ENGINEERING These services have included establishment of standards for incentive wage payment plans to insure a full day's work for a full day's pay, labor contract negotiations, establishment of basic data for estimating, cost and labor control, preventive maintenance programs and plant layout, and protection.

METHODS Knight engineers have completed analyses of methods to reduce time and motion to a minimum and to establish the most efficient rigging to permit full utilization of existing personnel and equipment. A method study should always be tied in with establishment of incentive wage plans.

COST CONTROLS & BUDGETS The Knight organization has installed cost systems in more than 100 manufacturing plants, including foundries, to establish better and simple controls, "highlight" inefficiencies and establish budget goals for all levels of supervision and management. Every foundry must know its costs to insure continued profitable operation, competitively. A periodic review or audit by Knight Engineers insures that this "tool" of management is kept up to date.

PRODUCTION CONTROL Delivery promises always are important and sometimes critical. Systematic production scheduling and control based on known factors requires a minimum of people and insures a minimum of missed shipping dates.

A PARTIAL LIST OF CLIENTS

- **Acindar, S.A.**
  Buenos Aires, Argentina
- **Acinfer, S.A.**
  Villa Constitucion, Argentina
- **Alloy Steel Products Co.**
  Linden, N. J.
- **American Brake Shoe Company**
  Chicago and St. Louis
  Buffalo and New York
- **American Malleable Castings Co.**
  Marion, Ohio
- **American Radiator & Standard Sanitary Corp.**
  Baltimore and Louisville
- **Appleton Electric Company**
  South Milwaukee, Wisc.
- **Belle City Malleable Iron Company**
  Racine, Wisc.
- **Bergische Stahlwerke A.G.**
  Remscheid, Germany
- **Buckeye Steel Foundry Co.**
  Columbus, Ohio
- **Buderus 'sche Eisenwerke**
  Essen, Germany
- **Canadian Car and Foundry Company, Ltd.**
  Montreal, Quebec
- **Chrysler Corp.**
  New Orleans, La.
- **C. K. D.**
  Blansko, Czechoslovakia
- **James B. Clow & Sons Co.**
  Birmingham, Ala.
- **Combustion Engineering, Inc.**
  Chattanooga, Tenn.
- **Crane Co.**
  Chicago and Chattanooga
- **Cummins Engine Company, Inc.**
  Columbus, Ind.
- **Dalton Foundries, Inc.**
  Warsaw, Ind.
- **Dayton Malleable Iron Co. (3 plants)**
  Dayton, O.
- **Der Stahl- und Temperguss A.G.**
  Traisen, Austria
- **Dominion Foundries & Steel Limited**
  Hamilton, Ontario
- **Electric Steel Foundry Company**
  Portland, Ore.
- **Erie Malleable Iron Company**
  Erie, Pa.
- **Fahralloy Canada Limited**
  Orillia, Ontario
- **Fairbanks, Morse & Co.**
  Kansas City, Kan.
- **Federal Malleable Co.**
  Milwaukee, Wisc.
- **General Railway Signal Company**
  Rochester, New York
- **General Steel Castings Corp.**
  Eddystone, Pa.
- **Goetzewerke A/G**
  Burscheid, Germany
- **Gunite Foundries Corporation**
  Rockford, Ill.
- **Hammond Brass Works**
  Hammond, Ind.
- **Hardinge Company, Inc.**
  York, Pa.
- **Hauts-Fourneaux et Fonderies**
  Halbergerhutte
  Brebach (Sarre), Germany
- **Haynes Stellite Company**
  Kokomo, Ind.
- **Hershey Corporation**
  Havana, Cuba
- **Ilva**
  Genoa, Italy
- **A. Y. McDonald Manufacturing Co.**
  Dubuque, Iowa
- **Mannesmann-Meer A.G.**
  Munchen, Gladbach, Germany
- **Marion Malleable Iron Works**
  Marion, Ind.
- **Moline Malleable Iron Company**
  St. Charles, Ill.
- **Mueller Co.**
  Decatur, Ill.
- **National Roll & Steel Foundry Co.**
  Avonmore, Pa.
- **Ohio Injector Co.**
  Wadsworth, Ohio
- **OPW Corporation**
  Cincinnati, Ohio
- **Pittsburgh Steel Foundry Corporation**
  Glassport, Pa.
- **The Plainville Casting Company**
  Plainville, Conn.
- **Ransohoff, Inc.**
  Hamilton, Ohio
- **Rheinstahl Eisenwerke**
  Gelsenkirchen, Germany
- **Scullin Steel Company**
  St. Louis, Missouri
- **Sibley Machine & Foundry Corp.**
  South Bend, Ind.
- **Spojene Tovarny Na Obrabeci Stroje**
  Brno, Czechoslovakia
- **Stavanger Electro-Staalverk A/S**
  Jorpeland, Norway
- **Stockey & Schmitz**
  Gevelsberg, Germany
- **Stockham Valves & Fittings**
  Birmingham, Ala.
- **Sulzer Bros. Ltd.**
  Winterthur, Switzerland
- **Superior Steel & Malleable Castings Co.**
  Benton Harbor, Mich.
- **The Symington-Gould Company**
  Division of Symington-Wayne Corp.
  Depew, N. Y.
- **Universal Castings Corporation**
  Chicago, Ill.
- **Wagner Castings Company**
  Decatur, Ill.
- **Walworth Company**
  Kewanee, Ill. and Boston, Mass.
- **Wellman Bronze & Aluminum Co.**
  Cleveland, Ohio
- **Woodruff & Edwards, Inc.**
  Elgin, Ill.
- **Worthington Corporation**
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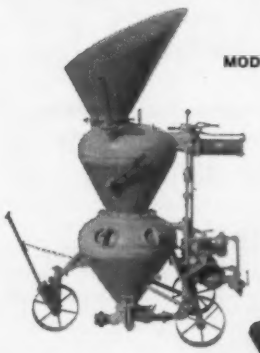
Blastcrete Gun

In ELECTRIC FURNACES, CUPOLAS and LADLES

Hundreds of foundries all over the country . . . from the smallest to the largest . . . have eliminated the use of block and brick. This is accomplished by using a BLASTCRETE gun which shoots denser linings, faster (usually ⅓ the time of other type guns). The Blastcrete gun's ability to handle extremely damp materials (such as rebounds) is only one of its many outstanding features. So superior is the BLASTCRETE GUN that more and more companies have discarded the gun formerly used after a FREE trial run with this outstanding refractory gun in their own cupolas.

A FEW COMPANIES THAT HAVE CHANGED TO THE BLASTCRETE METHOD:
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Find out why hundreds of companies have replaced their air placement gun with Blastcrete.



MODEL PM-1



MODEL BG-3

Electric furnaces, either acid or basic, are being successfully lined (both side walls and arches) with Blastcrete Guns. Thousands of dollars in savings over the former brick and hand ram method are realized.

FREE TRIAL PROVES SUPERIORITY

A BLASTCRETE gun will be installed FREE in your plant on a NO OBLIGATION basis. Simply compare it with your present method or gun. Afterwards decide for yourself! Buy it or rent it . . . either way you'll want a BLASTCRETE!

BLASTCRETE RENTAL PLAN IS POPULAR

Many foundries choose the BLASTCRETE Rental Plan because the gun is used in the maintenance and repair of furnaces, ladles, etc., and can be written off as maintenance expense.

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THE PATENTED BLASTCRETE ANGLE NOZZLE

Developed for use in small cupolas, ladles, electric and reverberatory furnaces, is adaptable to any air placement gun (fits any size hose) and is available at the extremely low cost of **$55.00**

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Circle No. 153, Page 207

2 in 1 CUT-OFF

New swing-frame feature now included in standard Tabor-Brasive Table-Top Machine.

FULL RANGE

Cutting of all alloy steels, nodular and ductile iron.

ECONOMY

Less equipment to buy, space savings, less maintenance, proven Tabor-Brasive performance and design.

Now the best Foundry Cut-Off Machine is available with a swing-frame for full range cutting of alloy steels, nodular and ductile iron. See it at the Foundry Show—Booth 1613

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Circle No. 151, Page 207



Rugged, lightweight Transite Core Plates add new speed to precision core production

Asbestos-cement composition resists shock, breakage, corrosion . . . is easily cleaned

More and more experienced foundrymen rely on sturdy, finely sanded Transite® Core Plates for the smooth, level surface needed to turn out top-quality cores in minimum production time. The unusually light weight of the boards makes them easy to handle . . . also helps step up production.

How can Transite Core Plates stay smooth and true, even during baking and drying? They're fabricated of fibrous asbestos and cement in a special Johns-Manville process. Year in and year out, the rugged material stands up with a minimum of warpage and wear. Boards resist shock and corrosion, won't crack or break under normal conditions. Surfaces can be easily cleaned, too.

Transite Core Plates have proved themselves in hundreds of ferrous and non-ferrous foundries all over the country. If you haven't already done so, why not give them a chance to go to work, profitably, in your operation?

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Circle No. 150, Page 207

Continuous Automated Mulling

Uniform production rates in a foundry require a steady flow of constant quality molding sand. The latest breakthrough in meeting this need is continuous automated mulling, now in full production operation at Wolverine Brass Works. Here are some of the benefits realized by Wolverine from this new installation:

1. *Eliminated need for a full time man at the muller,*
2. *Sand properties consistently uniform, including moisture control to within ±0.1 per cent,*
3. *Sand supply in each molder's hopper automatically maintained,*
4. *Sand supply adjustable to production needs,*
5. *Overflow sand supply blended back in with shakeout sand,*
6. *Increased flowability, green strength and permeability of molding sand,*
7. *Castings with better surface finish and less hand finishing.*

by JACK H. SCHAUM, EDITOR

Would you like to have your foundry sand preparation system run continuously day in and day out without the need for constant attention and services of a muller operator? Wolverine Brass Works, Grand Rapids, Mich., accomplished this and many more benefits by installing a new-type continuous dual muller and electronic moisture controller plus automatic hopper filling at molding stations.

Here's a quote from conversation with Frank Steketee, foundry superintendent: "In our previous pug-mill mixing we had one man constantly adding water and testing the sand by 'feel'. Consequently

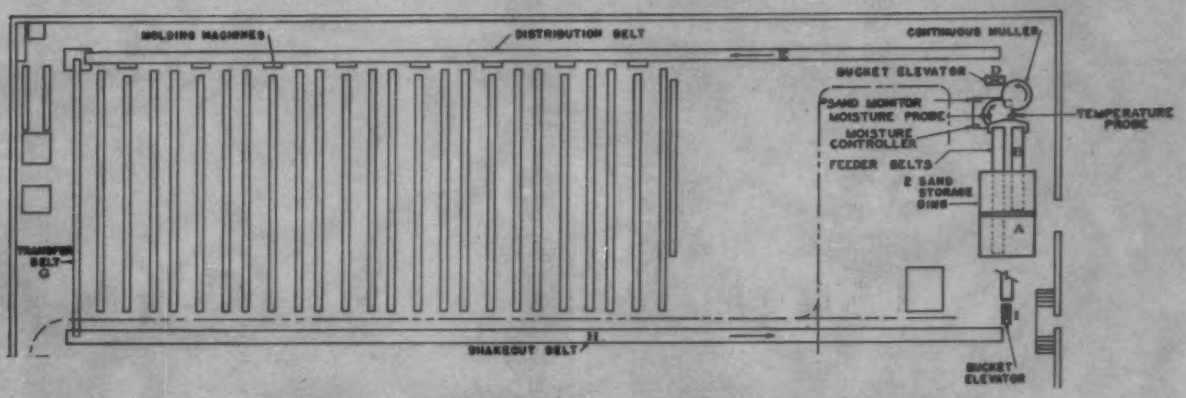


Fig. 1 . . . Floor plan of Wolverine foundry shows the path followed by green sand throughout the system.

moisture content varied throughout the day more or less in proportion to the attention given it by the sand technician. Now with twin mullers and electronic moisture control moisture never varies more than ±0.1 per cent."

Wolverine is in the business of making brass and bronze domestic and industrial plumbing fixtures. Ten molders jolt-squeeze enough molds to pour 15 tons of metal in an eight-hour shift. To satisfy this production rate, sand is continuously mulled in the new system at a rate of 17 tons per hour. Each of the two mullers is the size that would be used to mix 1000 lb of sand in conventional batch-mixing operations. A mixture of natural sand and clay-free sand running about 12 per cent clay is conditioned in the new system to a moisture content of 5.8-6.0 per cent.

The Tour

To best appreciate the merits of continuous mulling, let's take a round trip through the system. Our road map for the grand tour will be Fig. 1. Alphabetical letter references will locate the areas of interest. Continuous mulling at Wolverine was integrated into a system that originally used a pug mill. So a number of practices carry over from the old system but would not necessarily be included in a completely new installation. One of these is the large 40-ton storage hopper (A). As a starting point we see the system sand flowing from the bottom gate of this hopper. Gate is adjusted to satisfy the rate of flow desired in the system—17 tons per hour in the Wolverine foundry.

A rubber conveyor belt (B) carries the sand over to the dual muller system (C), where it enters in a steady stream. This sand is immediately assimilated in the 2000-lb batch of moistened sand which is constantly recirculating between the twin mixers. Muller plows turn over and advance a part of the sand a distance equal to about one-eighth of the circumference on each round trip. Both mullers operate at 30 rpm. At the point of tangency between the two muller housings, plows overlap just enough to exchange sand from one machine to the other. In Fig. 2 you are looking from the charge muller through this portal of sand interchange and into the second muller. The sand travels a figure-eight course—clockwise around the periphery of one mixer, then crossing over to follow a counterclockwise path in the other one . . . divide and mix . . . divide and mix . . . ad infinitum. Figure 3 is a schematic drawing showing this action.

Since sand is entering the charge muller continuously, provisions must be made for an equivalent discharge of muller sand. The exit gate in the discharge muller remains open all the time but an adjustable metal dam, 3-in. high at Wolverine, maintains a 2000-lb constant reservoir of sand in muller. This

Fig. 2 . . . View into the twin mullers reveals the portal between them (rear) and pipes for adding water.



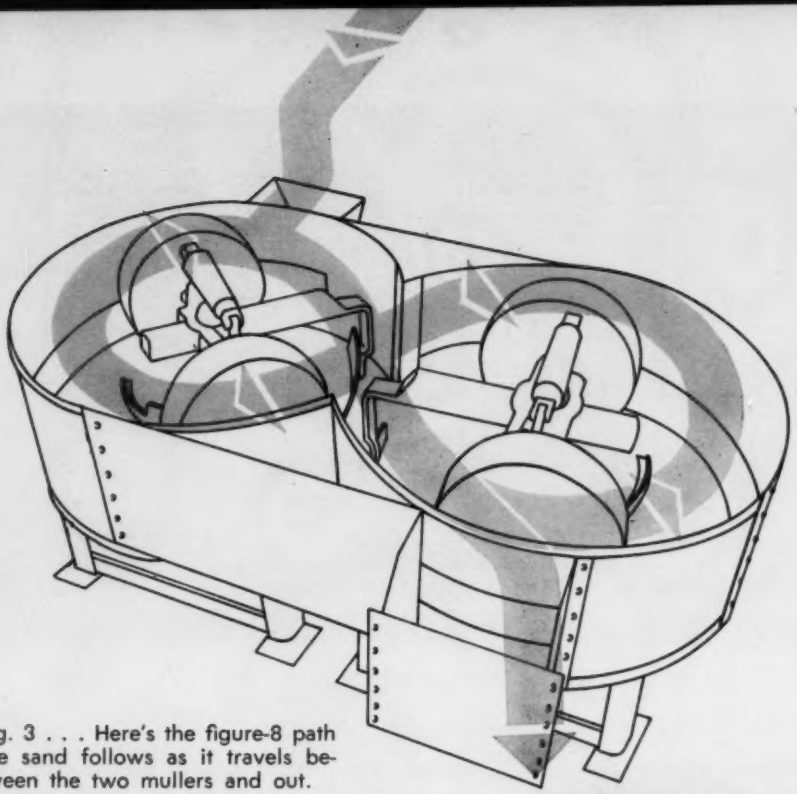


Fig. 3 . . . Here's the figure-8 path the sand follows as it travels between the two mullers and out.

assures intensive mixing of sand (an estimated five round trips in the figure-eight pattern during a period of about two minutes) before it eventually finds its way to the top edge of dam and escapes down a chute for distribution to molding stations. In Fig. 4 you can see the mulled sand dropping down the discharge chute on right.

Moisture Control

Meanwhile, what about the moisture control that has heretofore defied uniform, continuous control? Fortunately, electronics have supplied the solution to this puzzlement. Use is made of the fact that dry sand has a constant dielectric value that increases in direct proportion to the per cent of moisture surrounding the grains. Mounted in the charge-muller wear plate and flush with it is a two-element probe. Each time a muller wheel passes over the probe (once every second) it compresses the sand to a constant density permitting an accurate, instantaneous measurement of the electrical capacitance of the mix. Capacitance values are proportional to sand moisture content. If reading is below the desired level—5.9 per cent—a relay actuates a solenoid valve which opens the water line. Water flows out of several pipes located above and rotating with the charge-side mixer.

Arrow in Fig. 2 points to one of these pipes. Water continues to flow until capacitance reading indicates 5.9 per cent moisture content in the mix. Then relay shuts off the water. Moisture values oscillate around this control point in the very narrow range of 5.8 per cent minimum and 6.0 per cent maximum. Such control is all the more remarkable considering that



Fig. 4 . . . Mulled sand flows out discharge gate into chute.

sand entering the muller may vary from 1.5 to 4 per cent in H_2O content. If sand characteristics change you may want to change moisture content. Sand Technician John Jessalunas demonstrates in Fig. 5 (right) how you do this by a simple dial adjustment on control panel of automatic moisture controller.

Because sand temperature, as well as moisture content, has an influence on capacitance readings, an electronic correction for temperature must be superimposed into the moisture-control system. A temperature-sensing probe buried in the sand continually monitors this temperature information.

Hopper Level Control

Properly mulled and tempered sand flows continuously from the discharge gate of second muller down



Fig. 5 (left) . . . Automatic controls for plows on belt conveyor can be manually operated.



Sand technician (right) adjusts the electronic controls to desired moisture.

a chute to the boot of a bucket elevator (D). Sand is elevated to a horizontal sand distribution belt (E) running over the molding area. Arrow points to the belt. A climb up to the gangway alongside of the belt gives the view seen in Fig. 6. In each of the eight storage hoppers are two probes extending down to two different levels. Arrows in Fig. 6 point to top ends of these probes. At Wolverine, low-level probe "A" extends two feet down into the hopper and high-level probe "B" extends one foot. When level of sand in hopper falls below the end of probe "A" a control relay is energized so as to actuate a pneumatic cylinder which drops plow down onto belt. Plow diverts into the hopper a part of the continual supply of sand moving along on the belt (Fig. 6). Plow stays down until sand level in hopper rises high enough to cover end of probe "B". At this moment control relay is deenergized and plow raises to stand-by position. Probe levels are adjustable to suit the needs of the molding operations.

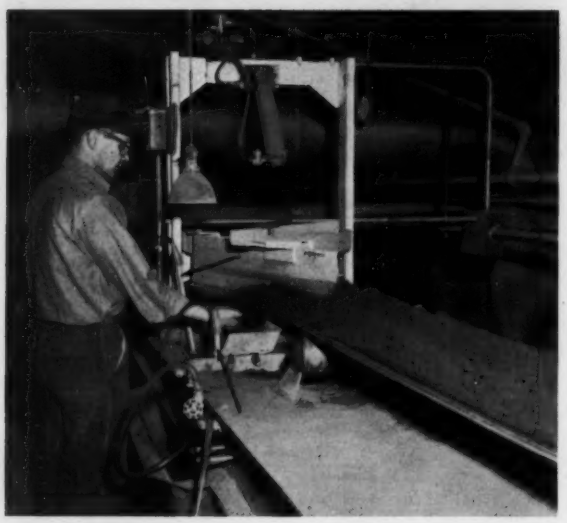
Similar automatic monitoring of sand level is going on in all the hoppers so every molder knows he has a comfortable supply of sand available at all times in his overhead hopper. The plows are designed so first plow extends only one-eighth of distance across belt, second plow two-eighths, and so forth until eighth plow extends all the way across the belt. This feature allows sand to enter as many as eight hoppers at once if by some rare chance they all called for sand simultaneously.

A panel down at the muller platform has a red and green light wired to each probe in each hopper. So when probe "A" in hopper No. 4 calls for sand and drops the plow, the No. 4 red light on the panel turns on. A glance at the panel tells instantly which hoppers are being filled. Immediately under each set of lights is a manual switch which permits any hopper control to be turned off. In Fig. 5 (left), Sand Technician Jessalunas is turning off controls on molding station No. 8 because the molder has finished his work for the day.

You probably wonder what happens when no hopper needs sand . . . especially since this is a continuous system in which the sand keeps coming at the same steady rate whether you need it or not. Any sand left on the horizontal distribution belt by the time it has passed over the last hopper just falls off the end onto a transfer belt conveyor (G). This overflow sand then moves to shakeout belt (H) which leads through shakeout area. Here it is joined by



Fig. 6 . . . Arrow in overall view of foundry (above) points to belt carrying sand to hoppers located at molding stations. Below is a close-up view of plow diverting sand into hopper. Arrows indicate probes.



shakeout sand and travels to an elevator (I) serving the large storage hopper (A), where our journey started.

BENEFITS

Continuous sand mulling has many direct as well as fringe benefits.

▶ Sand-flow rate through the molding system is extremely flexible. The 17-ton-per-hour rate at Wolverine can be throttled to any value down to zero or opened up to a maximum of 34 tons per hour. And the change can be made simply by changing the outlet gate on the sand storage hopper.

▶ If hot sand is one of your problems you can purposely run an excess supply of sand in your system. The larger the overflow sand supply the more you dilute the hot shakeout sand and drop its temperature.

▶ Another fringe benefit not to be overlooked is the mulling time saved. Usual practice calls for batch mulling sand for two minutes—the same length of time that the continuous system is mulling the sand. But the half minute formerly needed for charging and discharging is now eliminated. So it would take 25 per cent more time to batch mull the same quantity of sand in equivalent size mullers. By using larger mullers as much as 200 tons of mixed sand per hour could be provided in a continuous system.

▶ Although Wolverine already had two 40-ton storage bins in their plant, a continuous mulling system can reduce and even eliminate any need for sand storage—depending on how closely shakeout and molding are integrated.

▶ Foundry personnel are especially pleased with the molding benefits that accompany working with a sand that is consistently uniform. Improvements attributable to continuous mulling at Wolverine Brass Works are: 1) green strength raised from 6.7 psi up to 8.5 psi using the same sand previously used . . . 2) increased permeability . . . 3) reduced clay balls . . . 4) improved flowability . . . 5) sharper mold contours . . . 6) less mold tearing . . . 7) more uniform mold hardness . . . and 8) better casting surface finish.

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Additives...

. . . the second of four installments of the official 1959 exchange paper from the American Foundrymen's Society to the Australian branch of the Institute of British Foundrymen. This article started in the April issue and will be continued next month. Authors are: R. W. Heine, University of Wisconsin, Madison, Wis., E. H. King and J. S. Schumacher, The Hill & Griffith Co., Cincinnati.

Additives serve to enhance the normal properties of clay-sand-water aggregates. Among the many purposes which may be served by additives the following appear to be most important:

1) Flowability improvement.
2) Expansion control.
3) Casting finish improvement.
4) Mold edge and surface hardness improvement.

1 Flowability

Cellulose additives, such as fine wood or corncob flour, carbonized cellulose, etc., are commonly used to improve flowability. New sand needs about one per cent while used sand should carry about 0.15-0.25 per cent for each per cent of clay.* One effect of the cellulose is to cause the sand to become less sensitive to moisture content variation.

The strength of a used sand containing properly conditioned cellulose additives is compared with sand containing no additives in Fig. 1. Proper conditioning, to gain the effect shown in Fig. 1, occurs as the cellulose is charred by use and reuse. Effectiveness of the charred cellulose depends on its ability to absorb excessive free water in the sand. This prevents the clay from developing the characteristic stickiness which causes a loss in sand flowability. Water held in the cellulose is still partially available during ramming so adequate dry strength can be developed.

Some proprietary cellulose additives have further means of improving flowability such as ion exchange characteristics. Of course no additives will provide flowability if an extreme excess of water is added to the sand. Thus, flowability control involves use of proper moisture content together with additives.

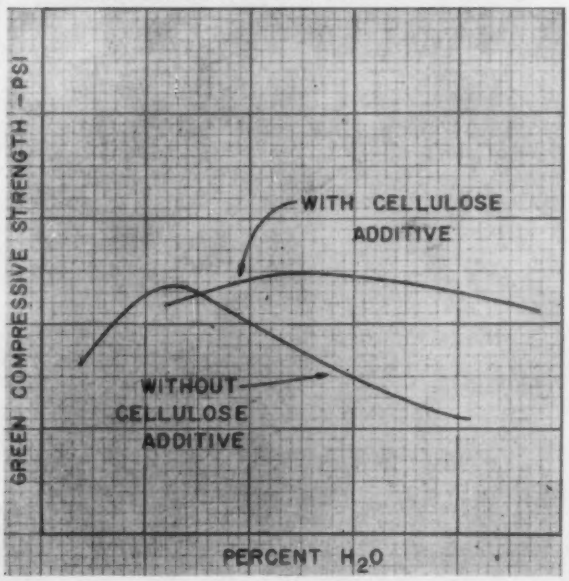
2 Expansion Control

Cellulose additions such as wood flour, carbonized cellulose, cob flour, etc., also prevent expansion defects, such as shown in Fig. 1. The percentages used are the same as for flowability purposes. The cellulose additions are said to burn out and permit expansion of the sand grains without the occurrence of buckling, rat-tailing or scabbing.

The authors observe that clays, in particular the bentonites, are more effective than cellulose additives in eliminating expansion defects—a very real advantage to using clay-saturated molding sand. The higher clay contents of clay-saturated sands virtually eliminate expansion defects, providing the casting is properly gated and poured. If expansion defects occur using a molding sand unsaturated with clay, raise the clay content by adding a higher than normal percentage of new clay at the sand mixer.

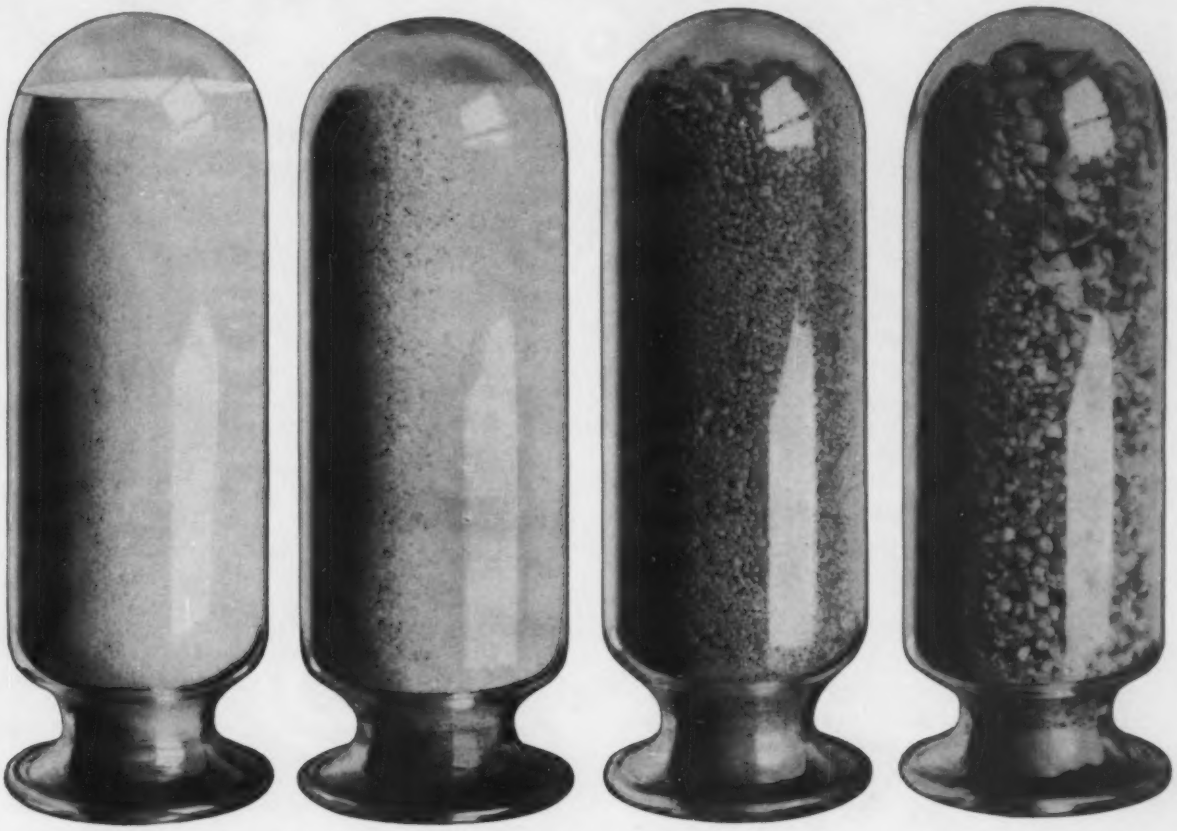
To prevent expansion defects, the clay in the sand must function as "new or effective clay." Effective

Fig. 1 . . . Note that the additive decreases sensitivity of sand properties to moisture variation.



* The amount carried in a used sand refers to the building up of total combustible matter in the sand by adding a fixed ratio of cellulose and other organic materials to the sand.

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Fig. 2 . . . Cellulose additions can eliminate surface defects like this.

clay may be defined as that percentage of clay in the sand which actually contributes to developing green compressive, shear and tensile strength.[1] This is to distinguish the "effective clay" from the conventional "AFS clay content."[2] The latter includes all particles of 20 microns or less in size whether they be silt, burned clay, organic matter or effective clay. Thus expansion defects may be eliminated through use of a clay-saturated sand practice or by additions of new clay to low clay content sands.

3 Casting Finish

Additives can also improve casting surfaces and reduce the time required to clean them. Sea coal, pitch, asphalt and other thermoplastic or thermosetting carbonaceous resins are commonly used for this purpose. These additives produce a reducing atmosphere in the mold and prevent reactions between casting and sand. Their effect also depends on carrying a certain percentage of residual carbonaceous material in the molding sand. Such carbonaceous matter is composed of two major fractions. First is the fixed carbon which is completely carbonized and is volatilized mainly by combustion.

Second is the highly volatile matter which can be destructively distilled by heat from the casting at temperatures of about 400 F to 1200 F. The volatile percentage is especially useful for creating a reducing atmosphere quickly in molds for small castings and thus obtain excellent finish. Highly volatile matter must be limited to less than about 3.0 per cent or various types of gas defects may arise. The limiting percentage depends on casting size. Proper use of the highly volatile matter permits production of small castings without adhering sand.

The fixed carbon fraction is especially effective for producing heavier castings. The extended time that the casting is at high temperature requires a nonvolatile, slowly oxidizable form of carbon. You may add as much as 12 to 15 per cent total carbonaceous material in sand for heavy castings.

To achieve fine surface finish, one must properly balance the total carbonaceous matter and the volatile and fixed carbon percentages in the sand with castings sizes, shape and alloy type. Sea coal provides such a balance to a limited degree. Particle size of the coal greatly influences the availability of the volatile ingredients. Table 1 lists some typical sieve analyses of sea coal used for different types of castings sizes. From 1 to 6 per cent new coal may be used in a new sand facing. About 2.0 to 15.0 per cent carbonaceous matter from this source may be carried in a sand according to casting requirements. Further improvements in balancing of volatile and fixed carbon fractions may be achieved by combining thermoplastic and thermosetting resins, coal, graphite and other materials. Thus additives may be designed for various casting size and alloy type requirements of particular foundries.

TABLE 1—SEA COAL FOR MOLDING SANDS

U.S. Sieve Numbers	Per Cent Retained			
	Grade CB	C-3 Coarse	D-4 Regular	D-4 Fine
	%	%	%	%
20	4.0- 6.0	3.0- 6.0	Trace	0
30	16.5-18.0	10.0-15.0	1.0- 3.0	0
40	16.5-18.0	10.0-15.0	8.5-10.0	1.0- 2.5
100	42.0-45.0	27.0-23.0	36.0-40.0	28.0-32.0
200	12.5-16.0	14.0-18.0	21.5-27.0	18.0-24.0
Pan	7.0-10.0	19.0-23.0	28.0-33.0	36.0-42.0

Typical Analysis (Dry Basis)

Moisture	— 2.35%	Fixed Carbon	— 58.60%
Sulphur	— 0.70%	Ash	— 3.96%
Volatile matter	— 37.44%		

Grade	Uses
CB	Railroad carwheels, chunky gray iron and wherever total combustibles are to be kept over 12 per cent.
C-3 Coarse	For general jobbing use of high metal load in the sand.
D-4 Regular	Most widely used grade in synthetic sands for medium weight gray iron and malleable castings.
D-4 Fine	For thin section iron castings.

4 Edge and Surface Hardness

Molasses, dextrin, corn syrup and cereal are additives used in sand to improve edge and surface hardness. These additives are partially or wholly water-soluble. They function as an adhesive when some evaporation of water occurs and thus develop edge and surface hardness. Used within their solubility limit—about 0.25 to 1 per cent. An excess produces a pasty condition harmful to flowability. Cereal, however, is partially insoluble. The insoluble portion produces a pasty condition which is desirable in low clay content sands. The loss in flowability gained from the cereal prevents dense ramming and thus inhibits expansion defects normally expected in low clay content sands.

References

1. Heine, R. W., King, E. H., and Schumacher, J. S., **Green Tensile and Shear Strengths of Molding Sands,** TRANSACTIONS, American Foundrymen's Society, v 67, 1959, p 229.
2. **Foundry Sand Handbook,** American Foundrymen's Society, 1952, p 96.

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Wall Colmonoy Corp., Detroit, Michigan, uses this Hevi-Duty laboratory crucible furnace to find exact melting temperatures of hard-surfacing and brazing alloys. Furnace heats rapidly to the 2200° F. temperature required, provides precise control for melting and cooling tests on 250 g samples. User reports long element life at high temperatures. ***For more information, send for Bulletin 1246.***



This Hevi-Duty double-chamber, dry-hearth furnace melts 100 lb of aluminum per hour, 16 hours a day, 7 days a week at Alliance Mfg. Co., Alliance, Ohio. It can provide up to 200-lb-per-hour output and occupies little space. It maintains critical bath temperatures during charging. User states: "You can turn it on and forget about it." ***For complete information, send for Bulletin 593.***



Kawneer Company, St. Charles, Illinois, has installed a second pair of Hevi-Duty reverberatory furnaces for breakdown and holding in direct-chill ingot casting of four different alloys. Furnaces provide ± 10° F. control, pour at 1320° F., operate 24 hours a day. Capacity is 100,000 lb a day. Note in the foreground two of the 6,300-lb aluminum ingots produced. ***Please write for Bulletin 591.***

The Fluidized Bed . . . for Investment Castings

By F. C. Quigley and Eugene DeLuca
Watertown (Mass.) Arsenal

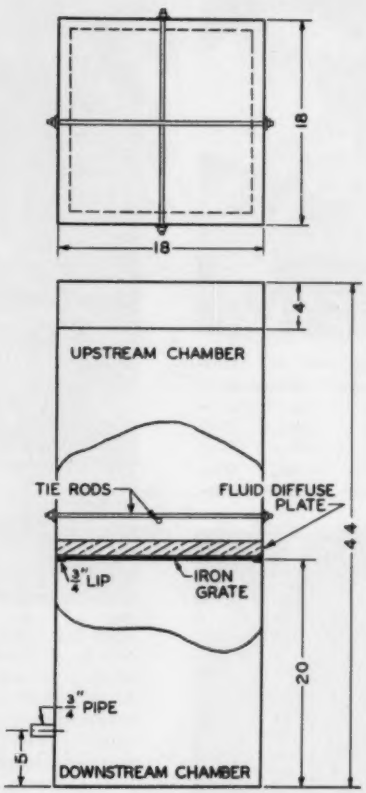
Recently developed ceramic shell coating processes for the production of investment castings involve the application of multiple alternate coats of slurry and solid particles on tax patterns to build-up a relatively thin-walled mold.

Heretofore, the coarse granular refractory particles were applied manually or directed mechanically onto the slurry precoat by action of gravity. This method is time consuming, requires an excessive amount of manipulation of the form by the operator, and, in the case of complex patterns, does not readily yield a uniform particle coating.

Solid fluidization is the process of imparting to a particle bed a state of continuous agitation. Gas-solid fluidization is accomplished by passage of a gas up through a bed of solid particles. The bed, in its agitated or fluidized state, behaves in many respects like a liquid. This phenomenon should allow the complete immersion of wet forms such as precoated wax patterns into a fluidized bed for particle coating.

The equipment used to accomplish fluidization of a particle bed is simple in design. A fluid bed system consists of two chambers separated by a horizontal fluid diffuse plate. The lower or downstream chamber is a high pressure chamber provided with the fluid inlet line. The upper or upstream chamber contains the fluid bed. The diffuse plate provides uniform fluid distribution into the upstream chamber. Watertown Arsenal designed and built a unit for fluidization of a particle bed, see drawing.

Dimensions of the upper chamber were selected so as to provide for the immersion of large wax pattern assemblies, ease of the immersion operation and the existence of a volume above the bed to insure solid streamer recovery during operation. Height of the downstream chamber is 20 in.; height of the entire unit is 44 in. The unit



measures 18 in. square. Construction material for the system is U. S. Standard 20-gage sheet metal. Although the metal does not satisfy one criteria—rigidity, it's low in cost and easily operated.

Strategically-placed tie rods maintain wall rigidity. Support for the fluid diffuse plate was provided by an iron grate set on a 3/4-in. lip projecting horizontally from the top of the downstream chamber. All plates were sealed in to prevent excess solid streaming. Compressed air was the obvious choice for the fluidizing medium. Alumina particles averaging 0.0138 in. and 0.0062 in. diameter and silica particles with 0.0117 in. average diameter were utilized in particle beds of varying fixed-bed height and constant fixed-bed porosity. Each of these three particles is currently used in mold production processes at Watertown Arsenal.

Complete fluidization of all particle beds was accomplished by use of a controlled fluid input from a 90 psi source. Particle coatings of each of the three size particles were applied to all available size and shape variations of pre-wetted patterns by immersion into the fluidized bed, see Fig. 2. In comparison with the former method, fluidization demonstrated the following advantages: required but a few seconds of labor . . . involved a smple movement of the form . . . coated all forms rapidly and evenly . . . eliminated the possibility of pattern damage by a particle stream . . . reduced the amount of lost solids . . . eliminated atmospheric pollution by dust . . . and the equipment is far less costly than any mechanical unit used for continuous coating. Maintainance of the system merely involves a periodic screening of the particle bed to remove impurities accumulated during operation.

Fluidized systems for particle coating are now operating most successfully at Watertown Arsenal in the production of standard investment casting molds and also in the production of new ceramic type precision molds.



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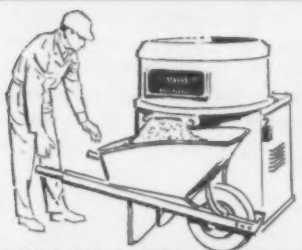
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S. C. Massari

Castings Congress Papers

Here is the 26th regular monthly Preview of Castings Congress Papers. Eight top-notch technical articles cover a diversity of metalcasting subjects . . . malleable iron heat treatment, shell sand coating, austenitic steel, cupro-nickel alloys, chilling of magnesium, epoxy resin patternmaking, copper grain refinement and die casting. The brief technical highlights that follow will help you quickly learn the significant progress unveiled in these papers.

TECHNICAL HIGHLIGHTS

White Iron Growth During Malleablizing . . . p 95
Many malleable foundries are installing protective atmosphere furnaces to prevent surface decarburization of their castings. In doing so they are discovering a new problem—excessive casting growth. This paper demonstrates how white iron growth can be minimized during annealing by encouraging surface decarburization with a wet controlled atmosphere anneal or by using gravel pack annealing.

Shell Mixing Process and Equipment . . . p 111
Probably the most significant recent improvement in shell mold and core sand practices has been in the switch over to coated sands. Cold coated sands develop adequate properties for foundries planning to blow solid cores, strainer cores or slab-type molds. But for the shop where it's contemplated to use coated sand for large shell cores which need draining or for shell molds, hot coating is recommended.

Heat Treatment MN-V-MO Steel .....p 115
Here's a new family of nonmagnetic steel casting alloys developed for structural applications aboard Navy minesweepers, for equipment used in proximity of magnetic instrumentation and for structures operating in strong electro-magnetic fields. The alloy is an age-hardenable MN-V-MO austenitic steel.

Cast 70/30 Cupro-Nickel Characteristics ....p 120
Pump designers are being pushed to meet demands for thinner walled pump sections which will withstand higher operating pressures. Couple this with requirements for resistance to salt-water corrosion and freedom from pitting by water velocity and you can appreciate why an improved 70/30 cupro-nickel alloy is a welcome arrival in the industry. Improved physical properties came from additions of 0.45 per cent columbium and an equal amount of silicon.

Porosity-Free Magnesium Castings .....p 131
Directional solidification is a prerequisite for producing sound castings. Chills are a popular foundry expedient for correcting casting configurations that seem to defy directional solidification. This study develops data to show chilling rates needed to produce porosity-free magnesium castings. Success is achieved when chilling produces a thermal gradient of 5F/in. in the solidifying metal before it has cooled to more than 50 F below the liquidus.

Plastic Patterns New Tools and Materials . . . p 139
Now that epoxy resins have firmly established themselves as a reliable material for patterns, improved practices are in order. This paper describes the newest technique—a gun for spraying epoxy resins on glass cloth and a gun for spraying metal fibers. The former saves 60 per cent labor in making plastic-glass cloth laminated patterns!

Grain Refinement of Copper .....p 144
Cast copper is notoriously prone to solidify with a coarse grain structure. Physical and chemical properties can be improved by reducing the grain size. In this work it was discovered that 0.50 per cent lithium or bismuth or combinations of both markedly refine as-cast grain size of electrolytic copper to 0.250 mm average grain diameter.

Low Pressure Die Casting .....p 154
From England comes a description of a highly successful process that permits casting aluminum holloware, rain-water goods, barrels, furniture and textile loom components. Essentially the technique involves expelling molten aluminum from a sealed iron crucible, up through a refractory coated iron tube, into the base of a permanent mold.

The AFS Castings Congress papers are the most authoritative technical information available to the metalcasting industry. Over 100 papers have been prepared by close to 250 authors for presentation at the 1960 Congress in Philadelphia, May 9-13. All papers receive preview publication in MODERN CASTINGS and then are bound into the annual volume of AFS TRANSACTIONS for permanent reference. Papers must be approved by the appropriate Program and Papers Committee of the sponsoring AFS Technical Division. They are then edited by AFS staff members C. R. McNeill and M. C. Hansen.

Written discussion of these papers is welcomed and will be included in the publication of the 1960 bound volume of AFS TRANSACTIONS. Discussions should be submitted to the Technical Director, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

WHITE IRON GROWTH DURING MALLEABLIZING

by N. R. Kelley and B. A. Ruediger

ABSTRACT

A study to determine the effect of decarburization, carbon concentration and annealing process variables including heating rate, annealing temperature, holding time and cooling rate on the growth or dimensional increase of white iron during malleablizing was undertaken. The experimental procedure consisted of determining growth by direct measurement of white iron test bars having different carbon analysis before and after several malleablizing cycles. The quality of the iron was evaluated by x-ray, fracture and microstructure studies.

The results, within the limits of the study, conclusively show that decarburization during malleablizing substantially retards growth, carbon concentration in the absence of decarburization determines growth and annealing variables have no effect on growth. Simultaneously it was shown that the smaller growth of white iron during gravel pack annealing is directly attributable to decarburization, and that a wet controlled atmosphere of appropriate analysis will retard growth as effectively even in short cycle anneals.

PREFACE

History records that between 1826 and 1832, Seth Boyden in fruitless attempts to produce whiteheart malleable iron, developed an entirely new process wherein more carbon was precipitated and remained in the iron as nodules. This new iron which had superior properties to the then conventional whiteheart iron was, in effect, a new ferrous material—"blackheart" or "American malleable iron."[4]

In the century which has passed since Seth Boyden's discovery, the fundamental process of malleablizing has shown little change, although the quality of our present blackheart iron undoubtedly surpasses the best of Boyden's day.

The improvements in the quality of today's irons resulted from the refinements that increased knowledge and competitive enterprise fostered. Typical examples are hot blast, duplexing, mechanized molding and protective atmosphere annealing. Unfortunately, advances in the art and sciences frequently are slow in evolution as evident by the development and application of protective atmosphere annealing.

N. R. KELLEY and B. A. RUEDIGER are with Industrial Heating Dept., General Electric Co., Shelbyville, Ind.

(Submitted by B. A. Ruediger to Rensselaer Polytechnic Institute in partial fulfillment of requirements for Master of Science degree.)

Conventional malleablizing practice for blackheart iron consisted of packing white iron castings in cast iron pots with slag, sand, silicon gravel, pebbles or mill scale, and annealing in batch type periodic furnaces. The packing material which minimized decarburization and distortion of the castings necessitated long annealing cycles of five to nine days because of the thermal lag between the work and the furnace temperature.[4]

Furnace Development

Improved periodic furnaces, such as the muffle-type where a double brick shell isolated the products of combustion from the castings, eliminated the need for pots and packing. Annealing cycles, however, still required seven to ten days since the inner refractory wall caused a large thermal lag between the heat source and the work.[4]

With the development of electric resistance heating elements and radiant tubes, a new series of furnaces which required neither packing or pots, and which drastically reduced thermal lag between the work and heat source, were developed. Typical of these were batch furnaces (such as the elevator and bell type) and continuous furnaces (such as the pusher and roller hearth). Annealing cycles were reduced from the conventional five to nine days to one to three days.

The atmosphere in these open annealing furnaces was generated by decarburization of the work. The depth of the decarburized skin on continuous annealed castings usually was light, however, since only a minor loss of atmosphere and/or introduction of air occurred during the charging and unloading operations. In batch furnaces where decarburization tended to be heavier, the addition of a small quantity of charcoal with the charge reduced decarburization quite effectively.

Between 1930 and 1940 a further improvement in malleablizing was realized by the development of atmosphere producing equipment. With this equipment it was possible to produce a nondecarburizing atmosphere such as purified exothermic gas[6] by the partial combustion of natural gas, butane, propane or coke oven gas and thus eliminate for all practical purposes decarburization of castings during annealing.

In the transition from gravel pack annealing to controlled atmosphere annealing, many problems were

encountered and systematically overcome. Typical of these is the problem which forms the basis of this thesis.

INTRODUCTION

Historical Review

Sometime during the last decade it was observed by metallurgists[10] that white iron chain when annealed in a self generated atmosphere[4] had a greater pitch than identical chain annealed by the conventional gravel pack process.[10] Subsequent tests performed by the author in 1957 using both a self generated and purified exothermic atmosphere[6] confirmed these observations. A thorough search of the available literature,[3,4,9] however, disclosed no further information on this growth phenomenon.

Since it is economically prohibitive to redesign all chain patterns to adjust for this increased growth, but economically advantageous to anneal in a gaseous atmosphere, the development of an open annealing process[4] whereby growth of chain could be held to established standards would be most desirable.

Statement of Problem

In particular, this thesis is concerned with determining the effect of the following on the growth of white iron during malleablizing:

1) Decarburization.
2) Carbon concentration.
3) Annealing variables of heating rate, first stage graphitization temperature, holding time at this temperature and cooling rate during second stage graphitization.

THEORY

Decarburization Effect on Growth

Literature[4] states that the principal functions of packing material such as slag, sand, silicon gravel or mill scale in gravel pack annealing are to minimize surface decarburization and distortion. Previous observations by the author and others[10] conclusively prove that a substantial amount of surface decarburization occurs during gravel pack annealing.

Thus it appears reasonable to conclude that:

1) The substantially smaller growth experienced in the gravel pack process is directly attributable to surface decarburization.
2) If surface decarburization retards growth then a controlled atmosphere having a high dew point (and thus a high decarburization potential) should also retard growth equally as well.

Carbon Concentration Effect on Growth

The malleablizing process for "blackheart" or American malleable iron can be written empirically as follows:

$$Fe_\alpha + Fe_3C \xrightarrow[Hold]{Heat} Fe_\gamma + C \xrightarrow[Cool]{Slow} Fe_\alpha + C$$

In essence, the process consists of converting cementite to alpha iron and graphitic carbon by a thermal cycle. The decomposition of cementite, however, takes place in two distinct steps, namely:

1) $Fe_3C \longrightarrow Fe_\gamma + C$ or the graphitization of cementite which yields gamma iron and graphitic carbon.
2) $Fe_\gamma \longrightarrow Fe_\alpha + C$ or the allotropic transformation of gamma iron to alpha iron with the accompanying precipitation of graphite.

Literature[3,4,9] indicates that for all practical purposes no other significant change occurs during malleablizing. No other elements with the exception of silicon are present to any appreciable extent. None of these elements including silicon undergo a permanent chemical or metallurgical change during the process, with the exception perhaps at the surface of the iron where some oxidation might occur providing conditions are conducive.

From the foregoing, therefore, it seems reasonable to conclude that in a nondecarburizing atmosphere the growth of white iron during malleablizing is primarily dependent on carbon concentration unless annealing variables have an effect.

Annealing Variables Effect on Growth

The malleablizing process, as described previously, consists of converting cementite to alpha iron and graphitic carbon by a thermal cycle. In particular, the thermal cycle consists of:

1) Heating to above the transformation temperature and holding at this temperature until the cementite and alpha iron are converted to gamma iron and graphitic carbon.
2) Cooling slowly through the transformation range (1370-1330 F) to convert gamma iron to alpha iron and graphite.

Since the malleablizing process in essence is only a decomposition process, it seems reasonable to conclude that unless other elements in the iron undergo physical changes, the annealing variables will not effect the growth of white iron during malleablizing.

Relationship Between Carbon Concentration and Growth

The concentration of cementite in white iron is dependent on the initial carbon concentration. Since the densities of cementite, alpha iron and graphitic carbon are known,[2,8] the theoretical growth of white iron during malleablizing can be calculated as follows:

1) Since the solubility of carbon in alpha iron is appreciably less than 0.025 per cent (solid solubility at 723 C) at room temperature, the carbon in solution in ferrite can be neglected.
2) The weight of cementite and ferrite in a 100 gram sample of white iron of 2.00 per cent carbon content is:

$$3\,Fe + C \longrightarrow Fe_3C$$

$$\text{Wt. } Fe_3C = \frac{\text{Molecular Wt. } Fe_3C \cdot \text{Wt. C}}{\text{Molecular Wt. C}}$$

$$\text{Wt. } Fe_3C = \frac{179.56 \cdot 2.00}{12.01} = 29.901 \text{ grams}$$

$$\text{Wt. Fe} = 100 - \text{Wt. } Fe_3C$$

$$\text{Wt. Fe} = 100 - 29.901 = 70.099 \text{ grams}$$

3) The density of ferrite and cementite are 7.86 gms/cc[2] and 7.66 gms/cc[3], respectively.

The volume (V_w) that the 100 gram sample of white iron occupies is:

$$V_w = \frac{\text{Wt. } Fe_3C}{\text{Density } Fe_3C} + \frac{\text{Wt. Fe}}{\text{Density Fe}}$$

$$V_w = \frac{29.901}{7.66} + \frac{70.099}{7.86} = 12.822 \text{ cc}$$

4) The density (D_w) of white iron therefore is:

$$D_w = \frac{100 \text{ gm. sample}}{V_w} = \frac{100}{12.822} = 7.799 \text{ gms/cc}$$

5) The volume (V_M) that the malleablized white iron would have is (Density of graphite is 2.25 gms/cc[2]):

$$V_M = \frac{\text{Wt. Fe}}{\text{Density Fe}} + \frac{\text{Wt. C}}{\text{Density C}}$$

$$V_M = \frac{98.00}{7.86} + \frac{2.00}{2.25} = 13.357 \text{ cc}$$

6) The density (D_M) of malleable iron is:

$$D_M = \frac{100 \text{ gm. sample}}{V_M}$$

$$D_M = \frac{100}{13.357} = 7.487 \text{ gms/cc}$$

7) Since the density is equal to mass divided by the volume then the volume increase (V_1) which white iron undergoes during malleablizing is $D = M/V_1$. For a 1 cc sample of white iron the mass (M_w) is the density (D_w) divided by 1 cc. Thus the volume increase

$$V_1 = \frac{M_w}{D_M} = \frac{7.799}{7.487} = 1.04167 \text{ cc.}$$

8) Assuming that growth of white iron during malleablizing is anisotropic then the length increase (L_1) of a 1 cc sample is:

$$L_1 = \sqrt[3]{V_1} = \sqrt[3]{1.04167} = 1.0137 \text{ cm.}$$

9) The length increase in per cent is:

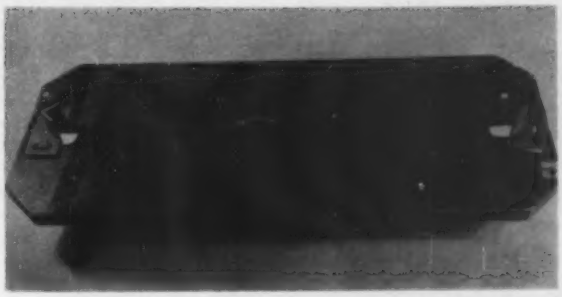
$$L_1\,\% = \frac{L_1 - \text{L original}}{\text{L original}} \cdot 100$$

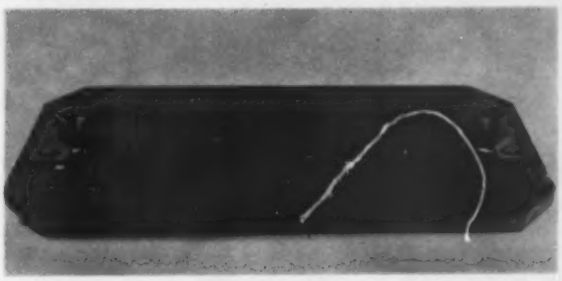
$$L_1\,\% = \frac{1.0137 - 1.0000}{1.0000} \cdot 100 = 1.37\%$$

Thus a sample of white iron having a carbon content of 2.00 per cent would increase 1.37 per cent in length after malleablizing.

Repeating the calculations for a 2.50 and 3.00 per cent carbon content white iron results in growths of 1.70 and 2.04 per cent, respectively.

Thus it seems reasonable to conclude that if carbon content controls growth in the absence of decarburization, the growths determined experimentally should be essentially the same as those determined by calculation. If the results obtained experimentally are not similar to those calculated, then variables other than those considered effect the growth of white iron during malleablizing.





Figs. 1 and 2 — Split pattern used by foundries for sand molds.

PROCEDURE

It was the purpose of this experiment to study the effect of annealing variables, carbon concentration and decarburization on the growth of white iron during malleablizing.

To perform this study a supply of white iron test bars and chain was obtained from five malleable foundries. Each foundry used the same split pattern for the sand molds (Figs. 1 and 2). The bars were all 1 x 1 x 12 in. in size with the exception of two tests where three 10 ft lengths of both No. 62 and No. 45 detachable link chain were used. Table 1 lists the suppliers of test bars by code, melting practice, chemical analysis and surface condition of the bars. Table 1 also shows that one supplier provided test bars of varying chemical analysis.

The bars and chain were shuffled and divided into groups and measured as discussed in this section.

After measurement the bars and chain were packed in a AISI 310 stainless steel retort, as shown in Fig. 3. The retort consists of a rectangular box having a sand seal to provide a gas tight box wherein a controlled atmosphere can be maintained. The retort is provided with a gas inlet pipe which is wrapped around the base of the retort. The controlled atmosphere is, therefore, preheated before it enters the retort.

Preheating the controlled atmosphere prevents thermal shock of the test bars and minimizes thermal gradients between the bars and the heat source. A central thermocouple pipe provides an entry for the load couple which for all tests was of the chromel alumel type. To avoid disintegration of the couple a new ceramic insulated couple was used for each test.

Test Control

The heat source used for all tests consisted of a saturable reactor controlled globar box furnace hav-

TABLE 1 — BASIC DATA ON TEST BARS AND CHAIN

Supplier Code	Test Bar or Chain Size, in.	Bar or Chain Chemistry*					Melting Practice	Bar Surface
		C	Si	Mn	S	P		
A-1	1 x 1 x 12	2.48/2.40	1.20/1.29	0.34/0.29	0.070	0.118	Cupola-air fce.	Sand or grit cleaned
A-2	1 x 1 x 12	2.34/2.32	1.20/1.27	0.26/0.23	0.075	0.104	Cupola-air fce.	Sand or grit cleaned
A-3	1 x 1 x 12	2.30/2.28	1.18/1.25	0.28/0.23	0.061	0.104	Cupola-air fce.	Sand or grit cleaned
A	No. 62 chain						Cupola-air fce.	Sand or grit cleaned
A	No. 45 chain						Cupola-air fce.	Sand or grit cleaned
B	1 x 1 x 12	2.73/2.82	1.27/1.28	0.51/0.51	0.102/0.169		Cupola-air fce.	As-cast
C	1 x 1 x 12	2.39	1.08	0.50	0.124	0.124	Cupola-air fce.	Sand or grit cleaned
D	1 x 1 x 12							Sand or grit cleaned
E	1 x 1 x 12							As-cast

*Chemistry was determined by analysis of one or more white iron bars by supplier.

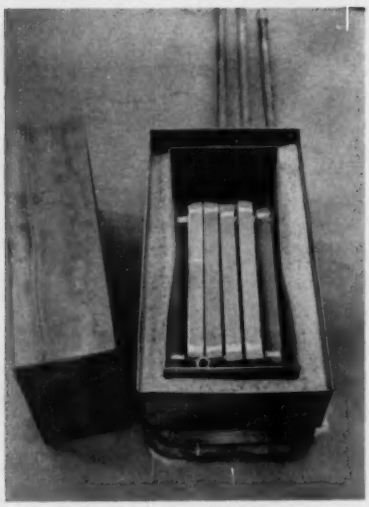


Fig. 3 — After measurement, bars and chain were packed in a stainless steel retort.

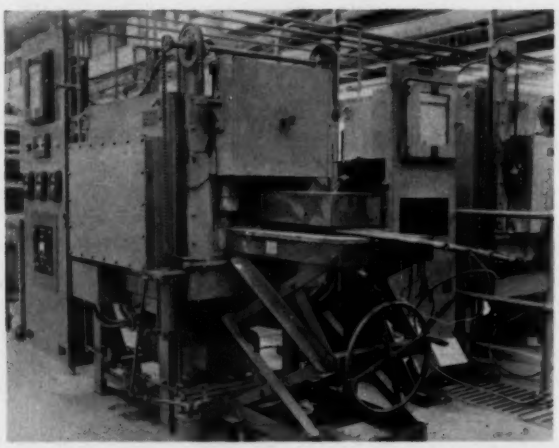


Fig. 4 — Heat source for all tests was a saturable reactor controlled globar box furnace having a maximum temperature of 2350 F.

ing a maximum temperature of 2350 F (Fig. 4). The annealing test cycles were controlled and recorded by use of a conventional program controller and strip chart recorder, as shown in Fig. 5.

Controlled atmosphere for the annealing tests was provided by use of a purified exothermic generator rated 2000 cfh (Fig. 6). The air to natural gas ratio was maintained at 9½:1. This provided a purified exothermic atmosphere having an analysis of 5.5 per cent CO, 5.5 per cent H_2, balance N_2. By either using or bypassing an activated alumina dryer the controlled atmosphere could be maintained at minus 40 F (0.0188 per cent water vapor) or plus 45 F (1.003 per cent water vapor), respectively. Analysis of the atmosphere was made by use of a conventional Orsat analyzer.

Annealing Cycles

The respective annealing cycles used for the experimental work were as follows:

Test 1. Introduce the retort containing test bars when the furnace is at 1400 F. Heat the test bars to 1700 ± 20 F at 200 F/hr. Hold the test bars at 1700 ± 20 F for 20 hr. Cool the test bars to 1420 F at maximum furnace rate. Control cool the test bars from 1420 F to 1280 F at 10 F/hr. Cool the test bars to 800 F or below at maximum furnace rate and remove test bars from the retort. Controlled atmosphere at 9½:1 air to natural gas ratio analyzing 5.5 per cent CO, 5.5 per cent H_2, balance N_2 at −40 F dew point (0.0188 per cent water vapor) used throughout annealing cycle.

Test 2. Repeat Test 1 above in its entirety, except use a +45 F dew point (1.003 per cent water vapor) atmosphere. The analysis of the atmosphere is identical to that of Test 1 except for water vapor.

Test 3. Anneal three each of A-1, A-2, A-3 and B test bars in pot type annealing furnaces at A-bar supplier's plant. Test bars are packed with gravel in sealed cast iron pots. The cycle consisted of heating

to 1620 F in 36 hr, holding 50 hr, cooling to 1400 F in 20.5 hr, slow cooling to 1300 F in 16 hr, rapid cooling to 1000 F and air cooling to room temperature.

Test 4. Anneal three C bars in pot type annealing furnace at C-bar supplier's plant. Cycle consists of heating to 1540 F in 45 hr, holding 40 hr during which temperature increases to 1570 F, cooling to 1400 F in 15 hr, slow cooling to 1315 F in 25 hr, furnace cooling to 1270 F in 6 hr. Air cooling pots will work to 1100 F in 9 hr and air cooling work to room temperature. Gravel packing was used.

Test 5. Anneal three D bars in pot type annealing furnace at D-bar supplier's plant. Cycle consists of heating to 1730 F at 230 F/hr holding for 13.75 hr, furnace cooling to 1400 F, cooling to 1280 F at 8 F/hr, furnace cooling to 1000 F and air cooling to room temperature. Packing for this test was 50 mesh silica sand.

Test 6. Repeat Test 1 in its entirety, only pack bars in gravel and seal. No controlled atmosphere was used.

Test 7. Repeat Test 1 in its entirety, only substitute three 10 ft lengths each of No. 45 and 62 chain for test bars.

Test 8. Repeat Test 2 in its entirety, only substitute three 10 ft lengths of No. 45 and 62 chain for test bars.

Test 9. Repeat Test 1 in its entirety, except heat to 1700 ± 20 F at 50 F/hr.

Test 10. Repeat Test 1 in its entirety, except hold at 1700 ± 20 F for 60 hr.

Test 11. Repeat Test 1 in its entirety, except raise first stage graphitization temperature from 1700 ± 20 F to 1800 F.

Test 12. Repeat Test 1 in its entirety, except cool between 1420 and 1280 F at 4 F/hr.

After the respective annealing cycles the bars were again measured and the per cent change in length or growth recorded.

X-Ray Examination and Fracture

At the completion of the final measurement a statistical sample of test bars were x-rayed by a commercial laboratory using a 250 kva machine and the resulting negatives studied for casting flaws.

Following the x-ray procedure, all test bars were fractured with a 250 ton hydraulic press to evaluate the degree of anneal and study the macrostructure for decarb, residual pearlite, and mottling.

One half of the fractured bars were sampled by drilling in four random locations 3/8-in. below the surface to within 3/8-in. of the opposite side. The drillings were then thoroughly mixed and a one-half gram sample cut and analyzed for total carbon by use of an induction carbon determinator.

Micro Samples

Finally, one end of each bar was cut off and a micro prepared. The micros were polished in the conventional manner through 000 paper and then polished in sequence on a billiard cloth using levigated alumina, a micro cloth using diamond paste and on billiard cloth using gamma alumina. After polishing, the micros were etched in saturated solution of picric acid in alcohol for appropriate times.

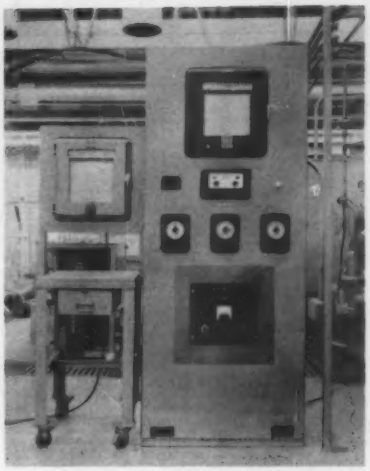


Fig. 5 — Annealing test cycles were controlled and recorded with a program controller and strip chart recorder.

Examination of the polished and etched micros was made by use of a mirror-reflector type metallograph at 50 to 100 diameters or above when necessary. The micros were studied to determine variations in nodule size, grain size, depth of decarb, presence of pearlite especially a pearlitic rim and the number of nodules in a 3 x 5 in. area from the surface inward and a similar area in the core.

Standardized Measurement Procedure — Test Bars

There are several ways by which the change in length of a specimen can be measured. For this study the direct method of measuring length before and after annealing by means of a cathetometer which can be directly read to 0.05 mm and estimated to 0.01 mm was used. To maintain a constant focal length between bars and the cathetometer each was fixed as shown in Figs. 7 and 8.

Several preliminary tests to evaluate different reference marks such as prick marks, notches, cross hair

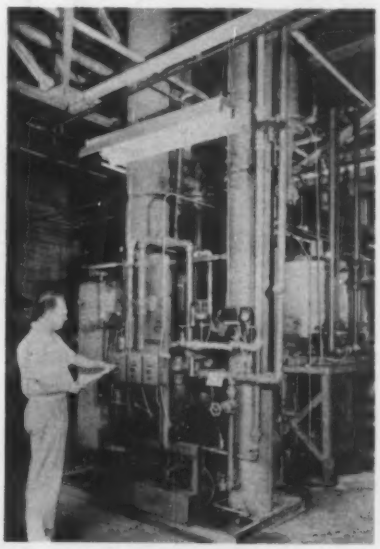
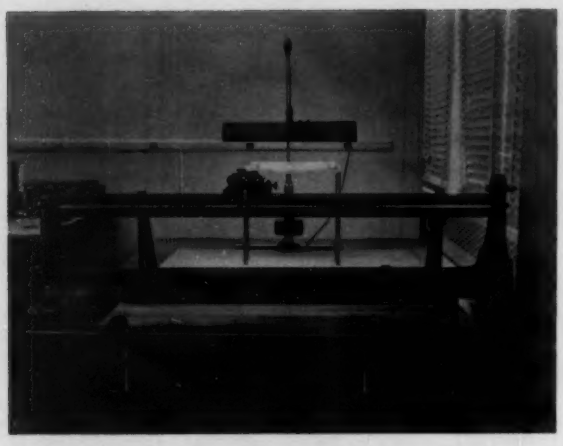


Fig. 6 — Controlled atmosphere for annealing tests was by use of a purified exothermic generator rated 2000 cfh.





Figs. 7 and 8 — To maintain a constant focal length between bars and the cathetometer, each was fixed in place as shown.

scratches and the accuracy of measuring changes in these surface marks as compared to parallel ground bar ends were made. These tests conclusively showed that:

1) Surface reference marks provide data that is slightly more accurate than measurements between parallel ground ends of test bars because some of the test bars were slightly bent before measurement and these tended to bend more during annealing. With the surface reference method the length change on the four rectangular faces was determined and averaged thereby eliminating the effect of distortion of the bars.
2) Of the reference marks evaluated, the prick mark was easiest to use both in initial marking and measuring.

The basic sequence used throughout this experimental work for measuring change in bar length was to 1) Select at random three bars each from the different groups (A-1, A-2, - - - D, E), 2) Grind the surface of the opposing ends of the four rectangular faces of each bar, 3) Code each bar to identify supplier, bar number, rectangular face and test number (eg: A1213), 4) Place prick marks on the center of each of the eight ground surfaces, 5) Measure the distance between the two prick marks on each of the four rectangular faces on the bar three separate times and average the three readings of each face, 6) After malleablizing remeasure as in 5 and 7) Determine the per cent change in length for each bar face and average the values of the four faces to determine the average growth of the bar.

Standardized Measurement Procedure — Chain

In the annealing tests using lengths of chain, a direct measuring procedure was also used to determine change in length or growth during malleablizing.

The procedure consisted of 1) Assembling sand or grit cleaned white iron chain links into 10 ft lengths, 2) Hanging chain length from suitable support and loading with 50 lb weight, 3) Measuring length at several locations between 72 links by means of a steel tape and averaging measurements, 4) Remeasuring as in 3 after annealing and 5) Determining the per cent change in length for each 10 ft chain length of the same size chain.

RESULTS AND DISCUSSION

Decarburization Effect on Growth of White Iron During Malleablizing

The experimental results of test bars annealed in a nondecarburizing atmosphere (Test 1) and a decarburizing atmosphere (Test 2, 3, 4 and 5) clearly indicate the appreciable retarding effect surface decarburization has on the growth of white iron during malleablizing. The extent of this effect is vividly shown in Figs. 9 and 15.

The fracture evaluation and microstructure study confirm the presence of a decarburized skin or bars annealed in both a wet purified exothermic atmosphere and gravel packing, as well as the absence of decarburization when annealing in a dry purified exothermic gas. The depth of the decarburized skin in test bars annealed in wet gas and gravel, as compared to the lack of decarburization in those bars annealed in dry gas, is shown in the photomicrographs (Figs. 10, 11 and 12).

In Test 6, the test bars were annealed in gravel for a cycle appreciably shorter than those common to pot-type annealing. Fracture evaluation and microstructure study of these bars revealed essentially no decarburization. The growth of these bars was equivalent to those obtained during a nondecarburizing anneal. Thus it can be concluded that gravel in itself has no effect on the growth of white iron during malleablizing.

The chain samples run in Tests 7 and 8 substantiated the results already determined in Tests 1, 2, 3, 4 and 5 that decarburization has an appreciable retarding effect on growth of white iron during malleablizing. In addition, however, the chain tests indicate when compared to results on 1 x 1 x 12 in. bars that the retarding effect on growth for a given decarburized skin depth is greater the smaller the cross-section of the white iron casting.

In other words, it appears that the growth of a small cross-section part can be retarded the same amount as a larger cross-section part with an appre-

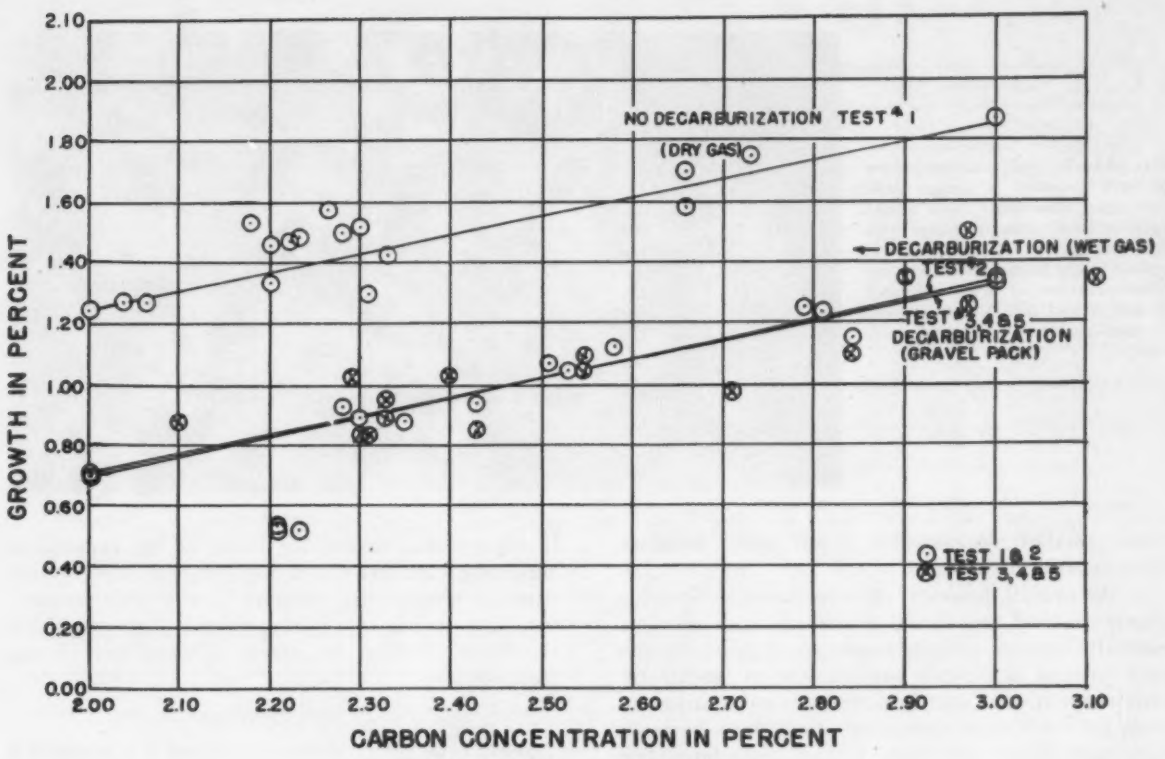


Fig. 9 — Annealing variables effect on growth of white iron during malleablizing.

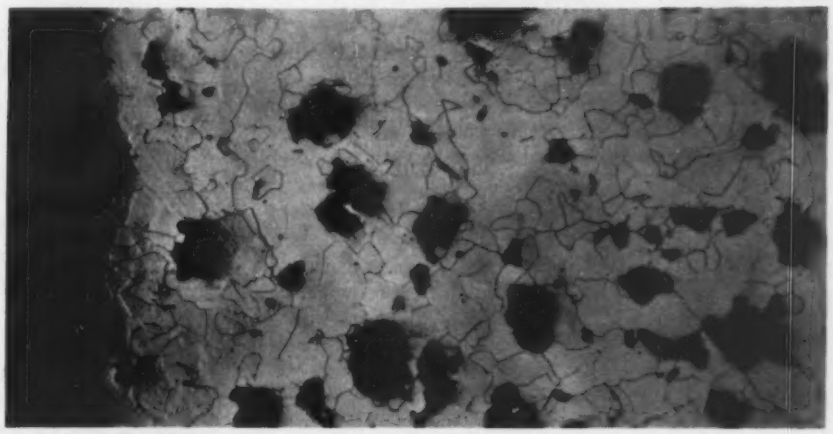


Fig. 10 — Typical microstructure of bars annealed in minus 40 F dew point purified exothermic atmosphere (test 1). Note absence of decarburization and uniform nodule size from surface to core. Microstructure of samples annealed in tests 6, 7, 9, 10, 11 and 12 were similar to that shown. Picric acid etch. 100 ×.

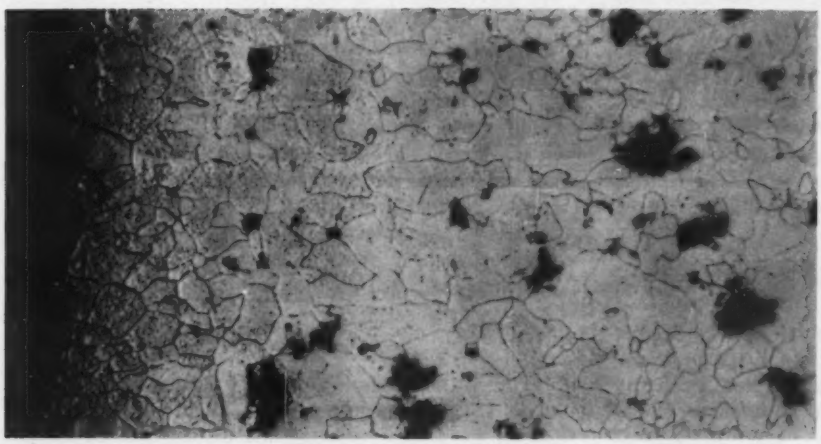


Fig. 11 — Typical microstructure of bars annealed in plus 45 F dew point purified exothermic atmosphere (test 2). Note decarburized skin, increasing nodule size and nodule count from surface to core, and absence of pearlitic rim. Microstructure of chain annealed in wet gas (test 8) was similar to that shown. Picric acid etch. 100 ×.

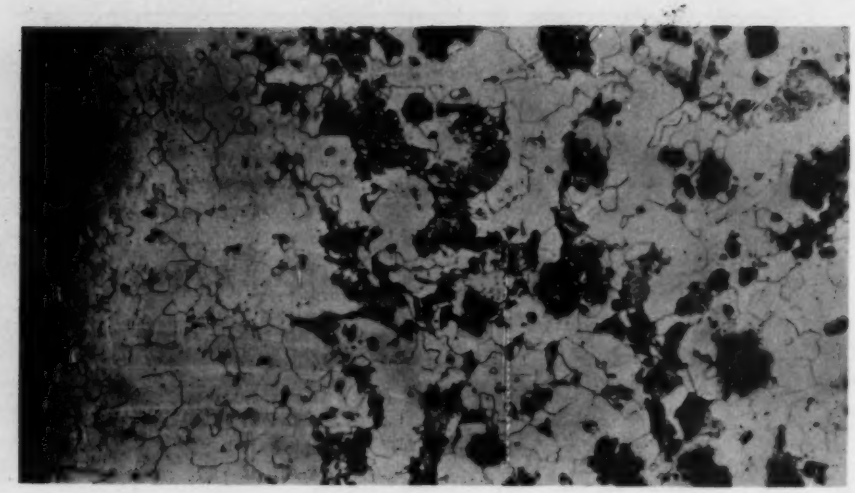


Fig. 12 — Typical microstructure of bars annealed in gravel pack pot type annealing ovens. Note decarburized skin, pearlitic rim and increasing nodule size and nodule count from surface to core. Microstructure of bars annealed in test 3 and test 5 were similar to that shown. Picric acid etch. 100 ×.

ciably smaller decarb skin depth and, therefore, amount of decarburization.

In the overall, however, the experimental work has clearly verified the initial hypothesis that the substantially smaller growth experienced in the gravel pack process is directly attributable to surface decarburization, and that if surface decarburization retards growth then a controlled atmosphere having a high dew point and thus a high decarburization potential should also retard growth equally as well.

Carbon Concentration Effect on Growth of White Iron During Malleablizing

From a theoretical consideration of the malleablizing process, it was concluded that unless the heat processing affected the growth of white iron during malleablizing, growth would be almost entirely dependent on carbon concentration of the annealed iron.

Figure 13, which compares the theoretical and experimental carbon concentration vs. growth curves, shows a 5 per cent divergence is attributed to the statistical unbalance in the sample size for high and low carbon content test bars. A study of the statistical distribution of the number of bars against carbon ranges shows that 64 per cent of the test bars used for the experiments contained less than 2.50 per cent carbon.

On a low (2.00-2.35 per cent), medium (2.36-2.70 per cent) and high (2.71 and over per cent) carbon split the percentages are 48.4, 34.4 and 17.2, respectively.

However, since the 95 per cent confidence limits of the experimental curve include the entire range of the theoretical curve, it seems reasonable to conclude that carbon content in the absence of decarburization determines, for all practical purposes, the growth of white iron during malleablizing.

Annealing Variables Effect on Growth of White Iron During Malleablizing

A comparison of the regression curves Fig. 14 for Tests 1, 9, 19, 11 and 12, whereby the effect of annealing variables on growth during malleablizing were studied, shows essentially no differences. Thus it appears that within the limits of the experiment annealing variables of heating rate, first stage graphitization temperature, holding time at this temperature and cooling rate during second stage graphitization have no effect on growth of white iron during malleablizing.

CONCLUSIONS

Within the limits of the experiment it is reasonable to conclude that the hypothesis set forth in the section on theory has been proved.

In effect this study (Fig. 15) has conclusively shown that:

1) The annealing variables of heating rate, first stage graphitization temperature, holding time at this temperature and cooling rate during second stage graphitization have no effect on the growth of white iron during malleablizing.
2) In the absence of decarburization, carbon concentration of the white iron determines its growth during malleablizing.
3) Decarburization during the malleablizing process substantially retards the growth of the white iron.

Furthermore, the experimental work has shown that gravel has no retarding effect on the growth of white iron during malleablizing. In the gravel pack annealing process the gravel packing by entrapping air and possibly through combined water resulting from a hygroscopic effect provides the decarburizing atmosphere which retards growth.

Finally, the experimental work has shown that it is possible to retard growth with a short cycle anneal using a wet controlled atmosphere as effectively as in the long cycle gravel pack annealing process. Thus an acceptable solution to the problem which confronts the malleable chain manufacturer of holding pitch to that obtained by gravel pack annealing is feasible with a short cycle, wet controlled atmosphere anneal such as that used in the experimental work.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to all those who contributed in making this

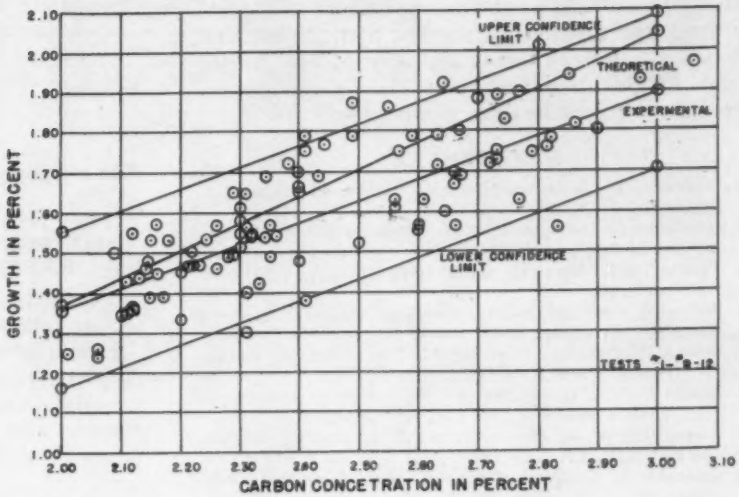


Fig. 13 — Carbon concentration effect on growth of white iron during malleablizing.

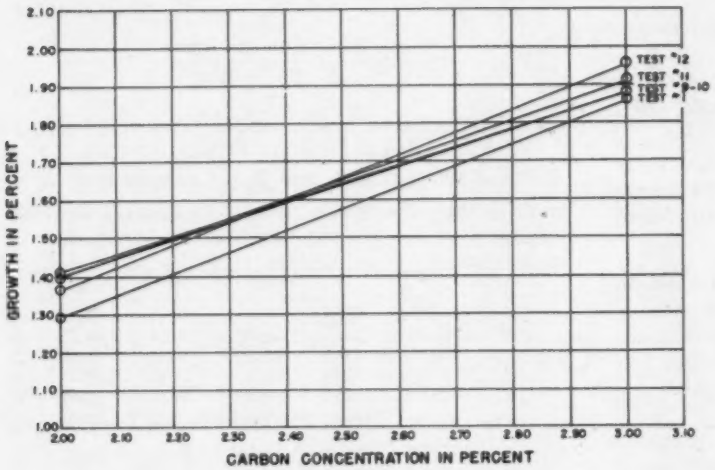


Fig. 14 — Composite graphs showing effect of annealing variables on growth of white iron during malleablizing.

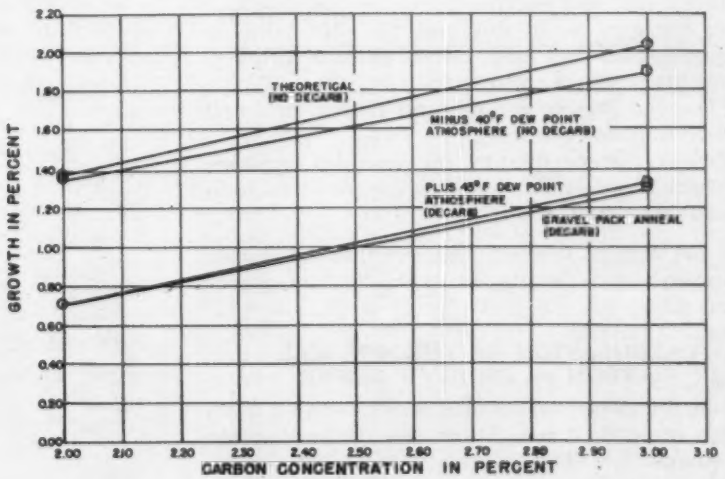


Fig. 15 — Comparison of effect of decarburization and absence of decarburization on growth of white iron during malleablizing.

project possible. In particular, the authors would like to thank the suppliers of the test bars, the General Electric Co. for the use of its facilities, Mr. August Ryan for his moral support and encouragement throughout the entire span of the project.

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APPENDIX

GROWTH VARIATION OF TEST BARS OF EQUIVALENT CARBON CONTENT

It is apparent from the preceding data that there are some variations, in the growth of test bars having equivalent carbon levels. This variation is attributed to one or more of the following:

1) The restraining effect of a decarburized skin on these as cast bars. Since the −40 F atmosphere is nondecarburizing, and yet several bars showed decarb skins after annealing, it seems probable that these bars were decarburized during casting.
2) Errors in measurement of the bars.
3) Errors in carbon analysis. This seems probable since sampling of cast metals which have inherent gross segregation is difficult. When the structure is such that the constituents on sampling tend to segregate, as in this case, the probability of getting a one-half gram sample which is truly representative of the entire bar is poor.
4) Effects of shrink, porosity and similar structural defects found in the bars.
5) Presence of pearlite in the annealed structure which would retain carbon in the combined form and thus retard growth.

In the overall, however, the variation was within acceptable limits as the many tables and graphs clearly show.

CALCULATION OF THEORETICAL CARBON vs. GROWTH CURVE

From the theoretical calculation of growth for given carbon contents, it is apparent that the realtionship is a straight line. The equation for a straight line is:

$$Y = a + bx$$

where

y = growth in per cent.
x = carbon concentration in per cent.
b = slope of curve.

thus:

$$b = \frac{y}{x} = \frac{2.04 - 1.37}{3.00 - 2.00} = 0.670$$

therefore:

$$a = y - 0.670\,x$$
$$a = 2.04 - 0.670\,(3.00) = 0.03$$

The equation for the curve is:

$$y = 0.03 + 0.670\,x$$

REGRESSION CURVE CALCULATION FOR EXPERIMENTAL GROWTH DATA

To determine the curve which best describes the typical relationship between variables, the regression line or line of average relationship was calculated by the least squares method.[1,7] It was assumed that the typical relationship between x, the carbon concentration, and y, the growth, was a straight line ($y = a + bx$) since the theoretical curve was a straight line.

By the least squares method the constants a and b of the equation $y = a + bx$ are defined as follows:

$$a = \frac{\Sigma x^2 \cdot \Sigma y - \Sigma x \cdot \Sigma xy}{N \cdot \Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{N \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{N \cdot \Sigma x^2 - (\Sigma x)^2}$$

where Σ denotes sum, and N the sample size.

From the experimental data the following were obtained:

Test No.	x	y	x^2	y^2	xy	n
1	34.68	22.06	80.79	32.75	51.35	15
9	51.50	34.14	128.30	56.24	84.67	21
10	50.85	33.68	123.95	54.49	81.95	21
11	50.95	33.99	124.75	55.42	83.05	21
12	52.35	34.77	132.23	58.29	87.69	21
1, 9-12	240.33	158.64	590.02	257.19	388.71	99
3, 4, 5	54.08	22.25	140.83	24.32	58.24	21
2	29.68	12.04	74.04	12.36	30.18	12

By substitution in the equations for the constants a and b the straight line equations for the respective tests are as follows:

Test No.	a	b	$y = a + bx$
1	0.154	0.569	$y = 0.154 + 0.569x$
9	0.467	0.472	$y = 0.467 + 0.472x$
10	0.434	0.483	$y = 0.434 + 0.483x$
11	0.371	0.514	$y = 0.371 + 0.514x$
12	0.195	0.586	$y = 0.195 + 0.586x$
1, 9-12	0.275	0.547	$y = 0.275 + 0.547x$
3, 4, 5	−0.493	0.603	$y = -0.493 + 0.603x$
2	−0.567	0.635	$y = -0.567 + 0.635x$

and therefore:

Test No.	For x = 2% carbon y =	For x = 3% carbon y =
1	1.292	1.861
9	1.411	1.883
10	1.400	1.883
11	1.399	1.913
12	1.367	1.953
1, 9-12	1.351	1.898
3, 4, 5	0.713	1.316
2	0.703	1.338

TABLE 2 — EXPERIMENTAL GROWTH DATA

Supplier	Test Bar No.	TEST 1		TEST 2		TEST 3		TEST 4		TEST 5		TEST 6	
		Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %
A-1	1	2.31	1.30	2.21	0.50	2.43	0.94						
	2	2.18	1.53	2.21	0.52	2.55	1.03						
	3	2.26	1.57	2.23	0.51	2.29	1.01						
A-2	1	2.28	1.49	2.35	0.87	2.30	0.83						
	2	2.22	1.47	2.30	0.89	2.10	0.87						
	3	2.20	1.45	2.28	0.92	2.33	0.95						
A-3	1	2.23	1.47			2.43	0.83						
	2	2.06	1.26			2.31	0.82						
	3	2.06	1.24			2.33	0.89						
B	1	2.30	1.51	2.81	1.23	2.97	1.49					2.83	1.64
	2	2.20	1.33	2.84	1.16	2.90	1.35					2.76	1.66
	3	2.33	1.42	2.79	1.25	2.90	1.35					2.67	1.39
C	1	2.66	1.70	2.51	1.06			2.71	0.97			2.36	1.52
	2	2.66	1.57	2.58	1.11			2.55	1.09			2.37	1.58
	3	2.73	1.75	2.53	1.04			2.40	1.02			2.30	1.52
D	1	2.67	1.66							3.11	1.34		
	2	2.73	1.44							2.84	1.10		
	3	2.98	1.36							2.97	1.25		
E	1	2.59	1.21									2.40	1.30
	2	2.58	1.14									2.50	1.39
	3	2.78	1.13									2.55	1.36

CONFIDENCE LIMIT CALCULATION FOR EXPERIMENTAL GROWTH DATA

To determine whether the deviation between the theoretical and experimental carbon concentration vs. growth curves is significant, the confidence limits for these tests (1, 9, 10, 11 and 12) were determined as follows:

$$Sy^2 = \frac{\Sigma(y^2) - [a\,\Sigma(y) + b\,\Sigma(xy)]}{N}$$

where Sy^2 is the square of the standard deviation. Substituting the appropriate values:

$$Sy^2 = \frac{(257.19) - [0.275(158.64) + 0.547(388.71)]}{99} = 0.0095$$

TABLE 3 — EXPERIMENTAL GROWTH DATA

Supplier	Chain Size	Chain Length No.	Test 7 Growth, %	Test 8 Growth, %
A	62	1	1.44	0.49
		2	1.24	0.39
		3	1.33	0.56
A	45	1	1.19	0.17
		2	1.18	0.11
		3	1.44	0.11

TABLE 4 — EXPERIMENTAL GROWTH DATA

Supplier	Test Bar No.	TEST 9		TEST 10		TEST 11		TEST 12	
		Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %	Carbon, %	Growth, %
A 1	1	2.36	1.54	2.30	1.61	2.31	1.53	2.30	1.55
	2	2.31	1.56	2.16	1.57	2.30	1.58	2.31	1.65
	3	2.29	1.65	2.30	1.58	2.32	1.55	2.32	1.54
A 2	1	2.14	1.48	2.28	1.49	2.12	1.55	2.22	1.46
	2	2.24	1.53	2.15	1.39	2.11	1.35	2.21	1.46
	3	2.12	1.37	2.09	1.50	2.15	1.53	2.22	1.50
A 3	1	2.14	1.46	2.34	1.54	2.12	1.55	2.13	1.44
	2	2.01	1.25	2.12	1.36	2.26	1.46	2.10	1.34
	3	2.16	1.45	2.31	1.40	2.11	1.43	2.17	1.39
B	1	2.43	1.69	2.34	1.69	2.82	1.78	2.44	1.77
	2	2.41	1.75	2.41	1.79	2.74	1.83	2.49	1.79
	3	2.55	1.86	2.38	1.72	2.57	1.75	2.40	1.70
C	1	2.72	1.72	2.60	1.57	2.64	1.60	2.81	1.76
	2	2.85	1.94	2.66	1.67	2.61	1.63	2.86	1.81
	3	2.73	1.73	2.60	1.56	2.67	1.69	2.79	1.75
D	1	2.49	1.87	2.73	1.89	2.70	1.88	2.80	2.01
	2	2.64	1.92	2.59	1.79	2.67	1.80	2.97	1.93
	3	2.90	1.80	2.77	1.90	2.63	1.79	3.06	1.97
E	1	2.77	1.63	2.50	1.52	2.35	1.49	2.56	1.63
	2	2.41	1.38	2.40	1.66	2.40	1.65	2.56	1.61
	3	2.83	1.56	2.40	1.48	2.35	1.57	2.63	1.71

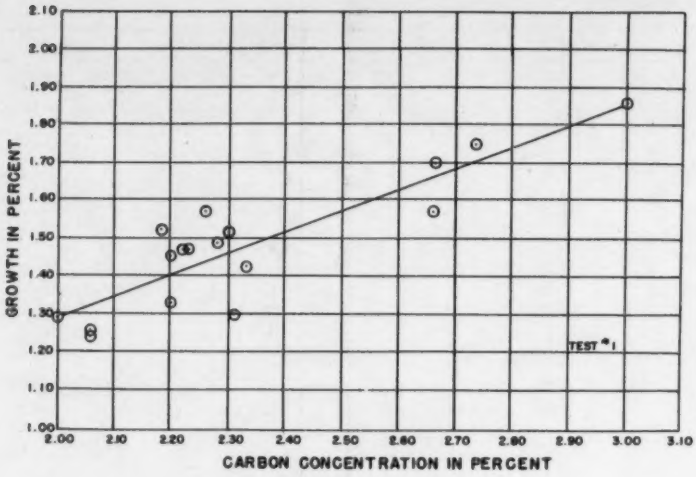
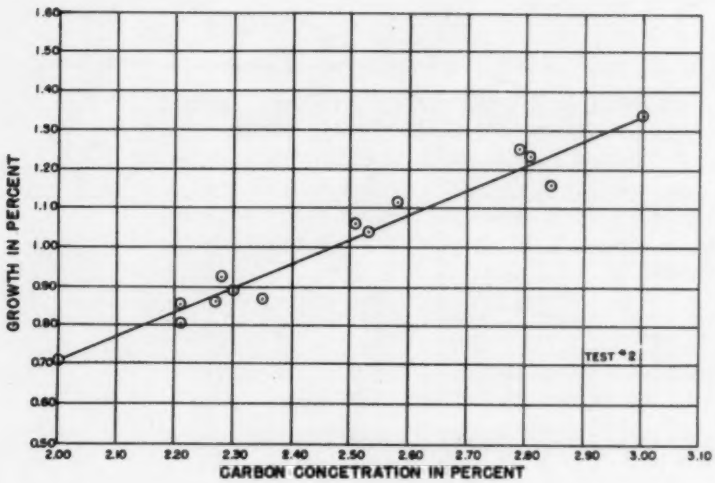


Fig. 16 — Annealing variables effect on growth of white iron during malleablizing, test 1.

Fig. 17 — Decarburization effect on growth of white iron during malleablizing, test 2.



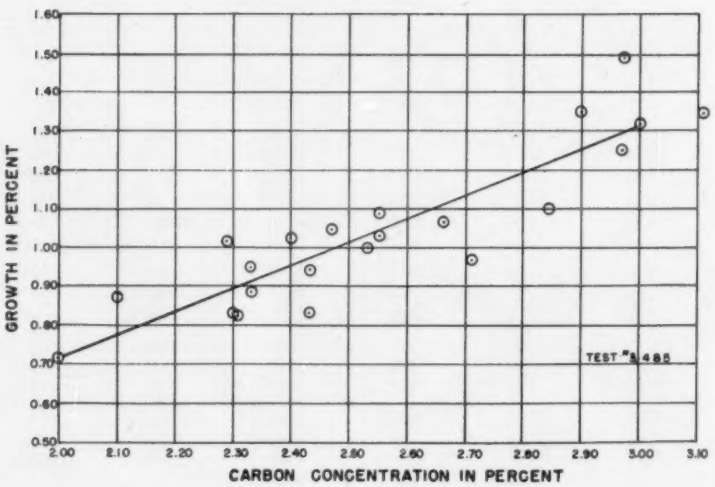


Fig. 18 — Decarburization effect on growth of white iron during malleablizing, tests 3, 4 and 5.

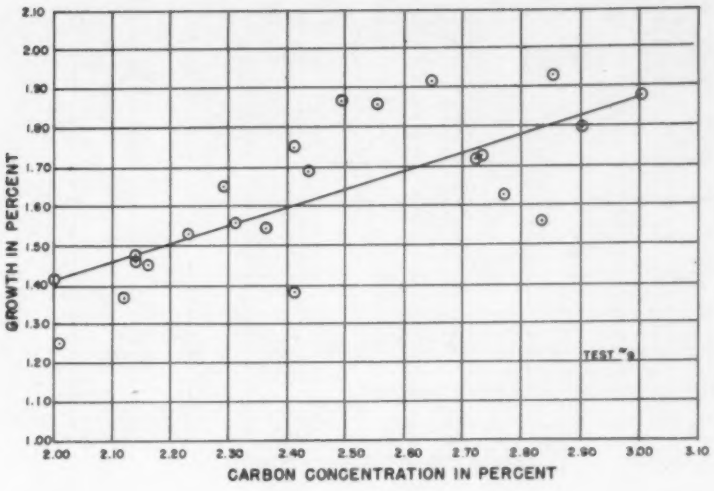


Fig. 19 — Annealing variables effect on growth of white iron during malleablizing, test 9.

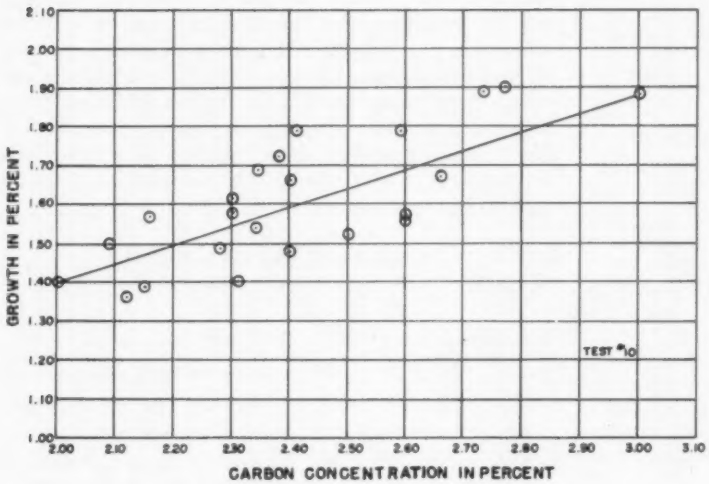


Fig. 20 — Annealing variables effect on growth of white iron during malleablizing, test 10.

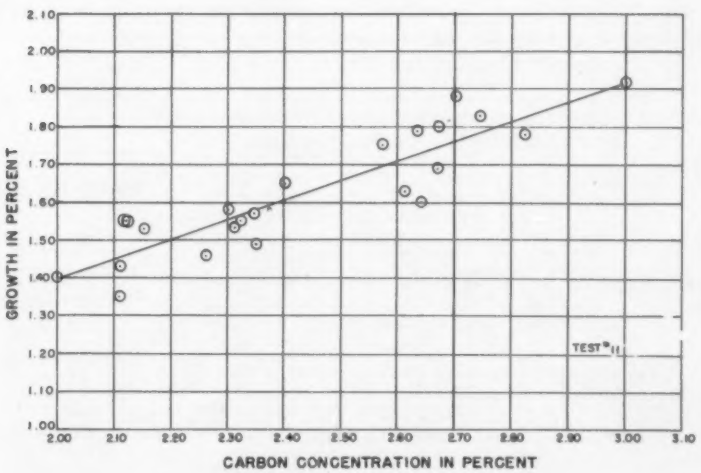


Fig. 21 — Annealing variables effect on growth of white iron during malleablizing, test 11.

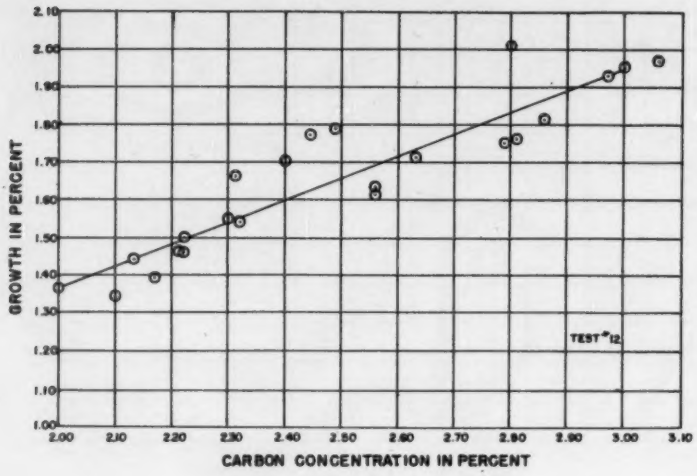


Fig. 22 — Annealing variables effect on growth of white iron during malleabliz-ing, test 12.

Correcting Sy^2 for the degrees of freedom:

$$\overline{Sy^2} = Sy^2\left(\frac{N-1}{N-2}\right) = 0.0095\left(\frac{99-1}{99-2}\right) = 0.0096$$

$$\overline{Sy} = \sqrt{\overline{Sy^2}} = \sqrt{0.0096} = 0.098$$

The confidence limits, therefore, are:

$$CL = \pm t\sqrt{\frac{\overline{Sy^2}}{N}}$$

where N = 1 for one sample and t = ± 1.98 for 95 per cent confidence limits.

therefore:

$$CL = \pm 1.98 \times 0.098 = \pm 0.194$$

For 2.00 per cent carbon iron $y = 1.351 - 0.194 = 1.157$
$y = 1.351 + 0.194 = 1.545$
For 3.00 per cent carbon iron $y = 1.898 - 0.194 = 1.704$
$y = 1.898 + 0.194 = 2.092$

STATISTICAL SAMPLE DETERMINATION OF TEST BARS FOR X-RAY EVALUATION

The sample size of test bars for x-ray evaluation was selected on the basis that if all the bars in the sample were found to be sound there would be a 99 per cent probability that all the bars in the group would be sound.

Based on a normal single sample plan,[5] the number of bars to be x-rayed for the various populations would be:

Supplier	Total No. of Test Bars	No. of Bars X-rayed
A-1	27	15
A-2	25	15
A-3	24	15
B	25	15
C	25	15
D	25	15
E	25	15

MICROSTRUCTURE STUDY

In view of the extensive effort necessary to prepare for metallographic examination micros from all samples, a reduced evaluation procedure was used. Two micros for each group of three test bars (eq. A-1, A-2, A-3—E) were prepared for Test 1, 2 and 3. For the remaining tests 4-6 and 9-12, only one micro per group of bars was prepared unless this micro showed a significant difference from Tests 1, 2 or 3, respectively, in which case the remaining two bars were examined. For Tests 7, 8 and 9, three links of each chain size for both the + 45 F and − 40 F dew point and gravel pack runs were examined.

TABLE 5 — X-RAY EVALUATION

Supplier	Bar Size, in.	Sample Size	Observations
A-1	1 x 1 x 12	15	Occasional light surface porosity
A-2	1 x 1 x 12	15	Occasional light surface porosity
A-3	1 x 1 x 12	15	Occasional light surface porosity
B	1 x 1 x 12	15	Centerline shrink in direction of long axis in all bars; severest of all 1 x 1 x 12 in. bars.
C	1 x 1 x 12	15	Centerline shrink in direction of long axis in 6 bars; evidence of large gas pockets.
D	1 x 1 x 12	15	Occasional centerline shrink in bars in direction of long axis and light porosity.
E	1 x 1 x 12	15	Centerline shrink in direction of long axis in 7 bars and some porosity.

SAMPLE SIZE vs. CARBON CONCENTRATION OF TEST BARS

If the test bars used for Tests 1, 9, 10, 11 and 12 are grouped in carbon concentration ranges the following distribution is obtained:

Carbon Concentration Range, %	No. of Bars
2.00 - 2.09	4
2.10 - 2.19	16
2.20 - 2.29	13
2.30 - 2.39	19
2.40 - 2.49	11
2.50 - 2.59	6

Carbon Concentration Range, %	No. of Bars	
2.60 - 2.69	12	
2.70 - 2.79	9	
2.80 - 2.89	6	
2.90 - 2.99	2	
3.00 - over	1	
Total	99	
		% of total
2.00 - 2.35	48	48.4
2.36 - 2.70	34	34.4
2.71 - over	17	17.2
Total	99	100.0

TABLE 6 — FRACTURE EVALUATION

Supplier and Bar No.		Test No. 1	2	3	4	5	6	9	10	11	12	Supplier and Sample No.	Chain Size	Test No. 7	8
A-1	1	TP-D	PC-D	D				TP	TPC	—	—	A 1	62	—	D
	2	TP	PC-D	D				TPC	TPC	—	—	2		—	D
	3	TP	PC-D	D				TPC	—	TP	TP	3		—	D
A-2	1	—	D	D				TP	TPC	—	TPC	A 1	45	—	D
	2	TP	D	D				—	—	—	TPC	2		—	D
	3	—	D	D				TPC	—	—	—	3		—	D
A-3	1	TP		D				TPC	—	—	—				
	2	TP		D				—	—	—	—				
	3	TP		D				TPC	—	—	—				
B	1	PC-D	TPC-D	TPC-D			TPC-D	PC	PC	PC	TPC				
	2	PC	TPC-D	TPC-D			PC-D	PC	PC	PC	TPC				
	3	PC	TPC-D	TPC-D			TPC-D	PC	PC	PC	TPC				
C	1	P	D		D		TPC	TPC	TPC	TPC	—				
	2	TP	D		D		—	PC	TPC	TPC	TPC				
	3	LP	D		D		TPC	PC	—	TPC	—				
D	1	P-M				P-D		P	TP	PC	TPC				
	2	P-M				TPC-D		LP	LP	P	PC				
	3	P-M				TPC-D		LP	TP	PC	TPC				
E	1	P					—	LP	LP	PC	—				
	2	P					—	LP	LP	LP	TP				
	3	P					—	LP	LP	—	—				

NOTE: Conditions found in bars denoted as pearlite (P), light pearlite (LP), trace pearlite (TP), decarb (D), pearlite core (PC), trace pearlite core (TPC), mottling (M), oxidation (O), and good iron (—). Blank spaces indicate no sample.

TABLE 7 — MICROSTRUCTURE STUDY

Supplier	Test No.	Nodule Count Surface	Core	Size Nodule	Grains	Structure
A-1	1	40	50	4d	6d	Bar 1 of CO A-1 showed 0.010 in. decarb. All bars of CO A showed a light pearlitic rim and some trace pearlite in the core.
A-2	1	40	50	4d	6d	
A-3	1	30	40	4d	6d	
B	1	30	50	4d	6d	Bars all showed 0.010-0.015 in. decarb. Light pearlite was present in rim and heavier pearlite occasionally in the core. All bars showed evidence of shrink.
C	1	25	40	4d	6d	Bars showed 0.010 in. decarb and pearlite rim. Light pearlite was also present in the core.
D	1	20	45	4d	6d	Two samples showed light decarb (0.010 in.). All bars showed heavy pearlite throughout.
E	1	35	35	4d	6d	One bar showed 0.010 in. decarb. All bars showed heavy pearlite throughout.
A-1	2	15	40	4d	6d	0.010 - 0.015 in. ferrite, 0.040 in. small nodule 5d, no rim.
A-2	2	10	30	4d	5d	0.015 - 0.020 in. ferrite, 0.040 - 0.060 in. small nodule 5d, no pearlite rim.
A-3	2	—	—	—	—	No test bars available for annealing.
B	2	15	25	3d	6d	0.010 - 0.015 in. ferrite 0.040 in small nodule 5d, no rim.
C	2	15	30	4d	6d	0.015 - 0.020 in. ferrite, 0.030 - 0.040 in. small nodule, no rim. Size of nodules in skin 5d.

(continued on next page)

TABLE 7 — MICROSTRUCTURE STUDY—*(continued)*

Supplier	Test No.	Nodule Count		Size		Structure
		Surface	Core	Nodule	Grains	
D	2	—	—	—	—	No test bars available for annealing.
E	2	—	—	—	—	No test bars available for annealing.
A-1	3	15	30	4d	5d	0.020 - 0.025 in. 6d nodules, 0.010 in. decarb, trace pearlite rim.
A-2	3	25	35	4d	5d	0.020 - 0.030 in. 6d nodules — trace pearlite rim.
A-3	3	20	35	4d	5d	0.010 - 0.020 in. smaller nodules (6d) — trace pearlite rim.
B	3	10	30	4d	5d	0.015 - 0.020 in. ferrite + 0.015 - 0.020 in. heavy pearlite rim.
C	4	10	30	4d	5d	0.020 - 0.025 in. ferrite + 0.040 heavy pearlite rim, 6d nodules to core.
D	5	10	30	2d	5d	0.010 - 0.015 in. ferrite, 0.020 - 0.030 in. heavy pearlitic rim, nodules 5d to core. Nodules star shaped, pearlite blotches in core.

TABLE 8 — MICROSTRUCTURE STUDY

Supplier	Test No.	Nodule Count		Size		Identification of bar or chain	Dew point, F	Structure
		Surface	Core	Nodule	Grains			
A-1	6	—	—	—	—			No test bars available for annealing.
A-2	6	—	—	—	—			No test bars available for annealing.
A-3	6	—	—	—	—			No test bars available for annealing.
B	6	15	30	5d	5d			0.005 in. decarb, surface shows scaling.
C	6	20	30	5d	6d			Trace pearlitic skin also some surface oxidation.
D	6	—	—	—	—			No test bar available for annealing.
E	6	25	35	5d	5d			Trace decarb, light pearlite skin and some light surface oxidation.
A	7	35	35	4d	7d	No. 62 chain	−40	Heavy pearlitic rim, shrink, some pearlite in core.
A	7	35	35	4d	7d	No. 45 chain	−40	Heavy pearlitic rim, shrink, some pearlite in core.
A	8	20	40	4d	8d	No. 62 chain	+45	0.020 - 0.030 in. decarb, heavy pearlitic rim, shrink in core. Nodules in core larger than in skin area.
A	8	10	35	4d	7d	No. 45 chain	+45	0.020 - 0.030 in. decarb, heavy pearlitic rim, shrink in core, nodules larger in core.

TABLE 9 — MICROSTRUCTURE STUDY

Supplier	Test No.	Nodule Count		Size		Structure
		Surface	Core	Nodule	Grains	
A-1	9	40	40	4d	6d	All bars showed trace pearlite in the core. Some samples showed a
A-2	9	30	30	4d	6d	light rim while others were free of pearlitic rim.
A-3	9	35	35	4d	6d	
B	9	20	35	6d	5d	Bars showed 0.010 in. decarb, shrink and pearlitic rim. Some pearlite in core was also evident.
C	9	35	35	6d	5d	A discontinuous pearlitic skin was evident and some light pearlite in the core.
D	9	30	35	6d	5d	A light pearlitic skin and some pearlite in core.
E	9	30	30	5d	5d	Trace pearlite in core and light pearlite skin.
A-1	10	40	40	5d	6d	A light discontinuous pearlitic rim was occasionally found in bars.
A-2	10	40	40	5d	6d	
A-3	10	35	35	4d	5d	
B	10	20	35	2d	5d	Bars were decarbed to 0.015 in. Shrink was evident and some pearlite in the core.
C	10	30	35	4d	6d	Light decarb (0.010 in.) was evident in one bar. A broken pearlitic rim was also evident.
D	10	30	30	4d	5d	A light pearlitic skin and some traces in core.
E	10	30	30	4d	5d	Traces of pearlite in core.
A-1	11	40	40	4d	6d	A light discontinuous pearlitic rim was found in bars.
A-2	11	30	30	4d	6d	
A-3	11	30	30	4d	6d	
B	11	20	30	4d	6d	Bars showed 0.010 in. decarb, shrink and a pearlitic rim. Some pearlite was also found in core.
C	11	30	30	4d	6d	A light pearlitic rim was evident and trace pearlite in the core.
D	11	35	35	4d	5d	A light pearlitic rim was evident.
E	11	35	35	4d	6d	A light pearlitic rim and traces in core.
A-1	12	30	30	4d	6d	A light discontinuous pearlitic skin was evident.
A-2	12	30	30	4d	6d	
A-3	12	30	30	4d	6d	
B	12	35	35	5d	6d	Shrink, decarb (0.010 in.) and a pearlitic skin were evident. Some trace pearlite was also found in the core.
C	12	30	30	5d	6d	A light pearlitic skin was evident and an occasional spot of pearlite in the core.
D	12	35	35	4d	6d	One bar showed pearlite in core others only traces.
E	12	30	30	4d	6d	Some light pearlite in core.

SHELL MIXING PROCESSES AND EQUIPMENT

For quality control of resin coated sand

by John Albanese

ABSTRACT

Foundrymen contemplating coated sand today can sometimes be confused by a myriad of sand coating processes available. Herein are described the various types of coating processes and the relative merits of each process. Phenolic resins and sand testing are discussed as they relate to the coating processes themselves.

Among the processes covered are cold, warm and hot coating, with emphasis on the importance of melt point control.

SHELL SAND MIXING PROCESSES

With the advent of the McCulloch Report describing the Croning process the foundries were given a new tool for the production of castings. This process described the use of a powdered resin intimately mixed with sand for use in producing shell molds. Unfortunately, the dry resin mix which was originally used in shell molding was found to have some serious drawbacks. The powdered resin, being much lighter than the sand, tended to segregate, and the material was difficult to blow. In addition, high resin percentages were required which increased the cost of an already expensive process.

In 1952, the first commercial equipment was developed for the production of resin coated sand. This process affected substantial economies in resin usage and paved the way for core blowing operations via shell cores. Since this original process, several other methods of coating sand have been developed which leaves the foundryman considerable latitude of choice when he is about to select his shell coating equipment. The purpose of this report, therefore, is to cover the various mixing processes so that the prospective user of coated sand can intelligently choose his equipment.

Coating Materials

In order to best explain the mixing processes, we should become acquainted with the materials for coating; phenolic resins and the methods of controlling the coating processes. The basic material for coating sand is the phenolic novolak. These novolaks are available in powdered, lump or liquid form and are thermoplastic materials. Thermoplastic is a term used to define resins which can be softened by heat and on cooling will retain their original properties.

If the basic material for coating is a phenolic novolak which, as said before would soften on heating, the question arises as to how can we strip a sand coated with novolak from the hot mold or pattern if the novolak itself will not harden under heating? Unfortunately, it is impossible. We must add another chemical called Hexamethylenetetramine which, when added to the novolak resin, will cause it to harden with the application of heat.

In essence, the hexa-novolak mixture flows under heat sufficiently to bind the sand particles, and then with continued heating and curing hardens into a heat resistant structure which can be stripped from the pattern or core box.

With this knowledge of phenolic resins, we can now pass on to the essentials of the coating process, which are:

1) Liquifying the resin for coating if it is not already a liquid.
2) Addition of hexa to create a thermosetting (heat hardenable) resin.

   NOTE: The powdered novolak resins are usually mixed with the necessary hexa.
3) Intensively mixing the hexa and resin while coating the previously dried sand grain.
4) Mulling to the desired extent, depending on the type of process.
5) Reduction of lumps which are created.
6) Cooling the sand prior to use.

Melt Point and Tensile Strength

Once the sand has been coated, it becomes necessary to evaluate the product. Of the many properties which can be determined, two control checks will suffice for most coated sand operations. They are melt point and tensile strength. The tensile strength refers to the baked tensile strength of the coated

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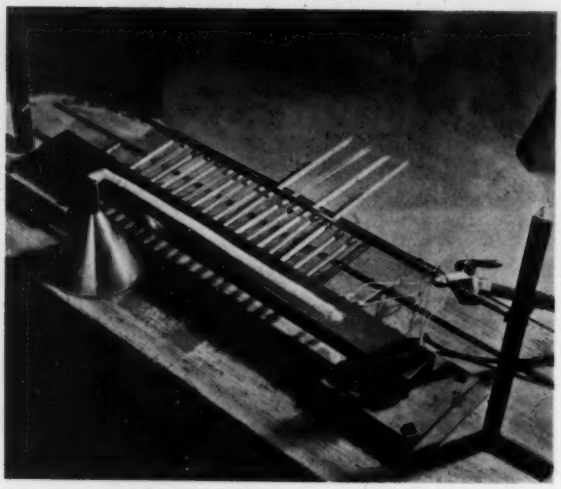


Fig. 1 — Melt point bar.

sand after a period in the oven. The method for making tensile briquets has been discussed previously and requires no elaboration at this time.

The melt point (sometimes called stick point) is a measure of the softening point of the phenolic resin on the sand grain. Figure 1 shows a melt point bar used for testing foundry sands. A strip of sand is placed on the brass bar and after 60 sec an air jet is passed over the sand to blow off any loose sand. The bar temperature at which the sand grains just bind is termed the melt point. The temperature gradient along the bar is obtained using small cartridge type heaters at one end, and the melt point is read from the thermometers in the bar.

The air nozzle has a $\frac{1}{8}$-in. orifice 2 in. away from the bar, and the pressure is carefully regulated to 10 psig. It is also a measure of the fluidity of the resin under heat and can be related to the performance of the coated sand in production equipment. Low melt point sand gives us a maximum tensile with a given per cent of resin but will tend to clump or pack in bins. Higher melt point sand will give less peel back or drop-off in foundry equipment, but the product is lower in tensile strength and takes longer to build up a given shell thickness.

It is, therefore, axiomatic that the most economical material which the foundry can use is the coated sand with the lowest possible melt point that will satisfactorily perform on that particular foundry's operation. Figure 2 shows the relationship between melt point and tensile strength of the silica sand.

Figure 3 shows the relationship between melt point and rate of mold build up.

Coated Sand Processes

Let us consider the various processes for coated sand and discuss their advantages and disadvantages.

The simplest method of coating sand is the cold process. This involves the use of liquid resins and hexa or powdered resins requiring alcohol to affect the solution. The process consists of coating the sand with resin and hexa, elimination of the volatiles to dry the mix, and the breakup of the doughy mass which has been formed during the mulling operation. This type of process can be run in a slow speed or high speed mixer.

The slow speed mixers have not met with much success as process time is long, and it is extremely difficult if not impossible to remove the last traces of volatiles. High speed mixers produce a better product in that shorter mixing times are possible due to the frictional heat built up during the cycle to aid in the removal of solvents. The main advantage of cold coating is in the capital expenditure required to produce the coated sand.

Experience has shown that cold coated sand is a somewhat variable product and does not have the uniformity that hot processes tend to develop. The reason for this variability is that the cold process is basically a drying process, and the final state of the coated sand is an equilibrium condition which will exist between the sand and the humidity of that particular day. Cold coating has been found to be most suitable for solid core work where no drain-out characteristics are required, or for example, where cores may be blown over a mandrel.

In view of the shortcomings of the cold process,

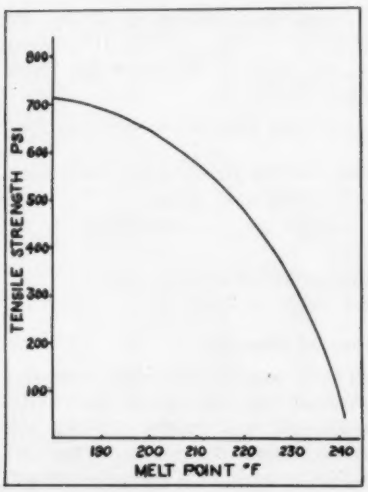


Fig. 2 — Effect of melt point on tensile strength, 60 AFS Silica sand, 3 per cent resin.

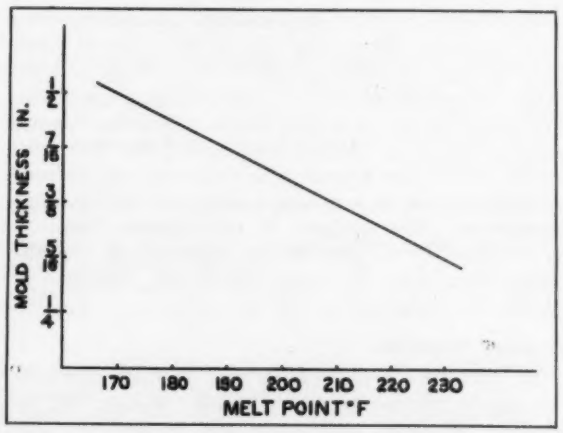


Fig. 3 — Mold thickness with various melt point sands, 450 F pattern, 20 sec dwell.

the muller manufacturers then added heat to their equipment. Processing of sand by the warm coating procedure is essentially the same as cold mixing. By blowing hot air through or at the sand, we are able to reduce the cycle, increase mixer capacity and make for a more complete removal of the volatiles. It is generally felt that this is a better quality sand, and its performance is more consistent on shell equipment when compared to the cold process.

Heat Effect on Tensile Strength

Figure 4 shows the effect on tensile strength of adding heat to a muller. These figures show the increase in tensile with increasing heat, and in addition there is a reduction in power to mix a given batch. A variation of the warm coating process is the use of warm sand; that is, sand about 150-225 F. This process appears to give substantially the same results as the warm air process. As indicated above, cycle times are shorter and the muller loading is reduced.

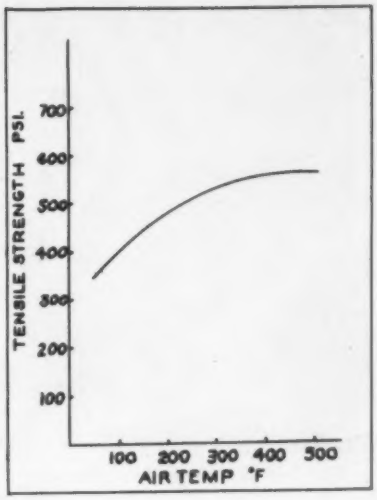


Fig. 4 — Effect of heat during mulling on tensile strength, 85 AFS Silica sand, 2.5 per cent resin.

It should be noted here that with the warm processes already discussed, there is no intentional reaction of the novolak with hexa. The sole function of the heat is to make for a complete removal of the volatiles, and the mixing is strictly a coating operation during which time the hexa and resin are thoroughly mixed. In either case, it is essential that the sand be completely coated before the volatiles are removed as premature evaporation of solvent can cause incomplete coating and resultant low tensile strengths.

A variation of the warm processes is the use of hot sand in conjunction with lump novolak resins. This process involves the heating of sand to approximately 325 F, adding the lump resin which melts and coats in contact with the heated sand. Following the coating period, the sand is then quenched with a water solution of Hexamethylenetetramine. The reason for the late hexa addition in this case is to prevent the novolak from reacting with the hexa. By quenching with water, the resin coated sand is cooled to a point where there is no significant reaction with the hexa. If reaction between the lump resin and hexa did occur, melt points would be extremely high and low tensiles would result.

The quality of coated sand produced from lumps is good, but the process lacks flexibility from the aspect of melt point control. Lumps in themselves are high melt point materials, and due to the inability to get lower melt points tensiles may be lower and buildup times on the shell machines somewhat long.

Liquid Novolak Use

A second type of hot coating process involves the use of a liquid novolak material in which there is an intentional reaction with the hexa to give us any desired melt point coated sand. This process involves the heating of sand to which liquid novolak and hexa have been added. After a period of time, the batch is quenched with water to arrest the reaction between the hexa and the resin at the desired melt point.

With this type of process, it is possible to produce any melt point sand from the same base resin. In all other processes the melt point of the sand produced is dependent on the type of resin introduced to the muller, and the foundryman's only function is to coat the sand.

Waxy Additives Use

Up to this point, the use of the waxy additives such as calcium stearate which are described in Patent No. 2,706,163 have not been discussed. These materials improve the flowability of the sand, reduce power consumption, and tend to increase the tensile strength. They may be added to start, end or at both the start and end of the coating process. The actual point of addition can depend on the mixing system used and the desired end product. Each foundry will have to determine the best type of addition to meet his own needs.

Another point not yet considered is the method of handling sand once it leaves the mixer. When coated sand is discharged it may be warm or hot and have a considerable number of lumps, which may be up to one or 2 in. in diameter. It is essential that the processing equipment subsequent to the muller, break down the lumps and cool the sand to a point where it will not reclump if allowed to stand.

A gyratory or oscillating screen has been found satisfactory for breaking down the lumps, while a low pressure pneumatic handling system will adequately cool sand the required amount. High pressure sand conveying systems which had been used for transporting oil bonded core sands met with mixed success. Preliminary trials with the actual coated sand used are recommended before purchase of this type of equipment is made.

It should be emphasized that material handling equipment after mulling is almost as important as the mixer itself and due consideration should be given it. Figure 5 shows the lumps in a typical batch of sand leaving the muller.

Any of these systems can be automated to any desired extent. It has been the writer's experience that automation to eliminate a single operator has not been warranted. An operator should be on hand to insure quality of the product. Systems are, however, available for automatic sand, resin and catalyst

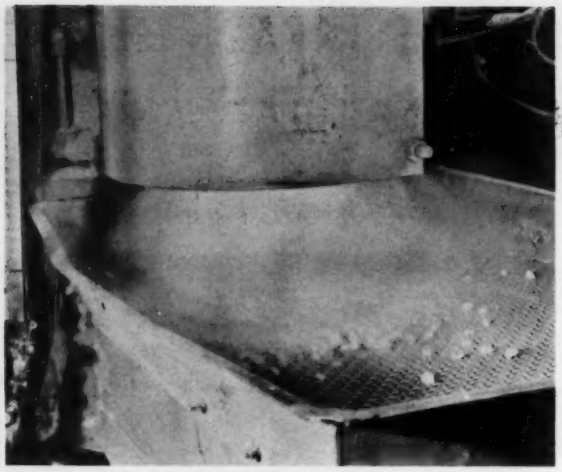


Fig. 5 — Coated sand on discharge.

addition which do not require a single operator.

Let us now consider the plight of the foundryman who is about to make a purchase of sand coating equipment. Before making any major decisions, he should ask himself:

For what purpose will the sand be used? If all the foundry plans to do with coated sand is blow solid cores, make strainer cores and stack pour using slab type molds, then a high melt point hot process is not easily justified as the cold coating process would supply adequate characteristics for this type of production. If, however, he is contemplating using this sand for large cores which need draining for most shell molding operations, he should definitely consider hot coating because of its increased reliability.

How much sand per hour will be needed? Unfortunately, he cannot base his muller capacity on figures obtained using an oil sand mixed in the same size muller. Resin coated sands are considerably more difficult to mull and muller capacity is usually reduced. Another consideration involving muller capacity is that high resin content sand mixes require much more power to mix and muller loads may have to be reduced, especially if an original production estimate was made on a washed and dried silica sand using a low resin content.

For example, a standard type mixer may handle 400 lb of a silica sand, using 4 per cent resin, while with a bank sand, 5 per cent resin would be required, and the muller loading may have to be reduced to approximately 300 lb. In order to best determine actual muller capacity, it would be advisable for the foundry to actually coat their own sand on the prospective muller and accurately determine both mulling cycles and capacity.

A certain amount of automation is desirable on any mulling unit but unless the muller man operates more than one muller, complete automation does not appear desirable or necessary. Among the considerations found helpful are automatic resin injection, timed mulling cycles which consist of automatic heat control, damper openings and discharge. The weighing of the resin and catalysts is a manual operation for which the operator has sufficient time. Figures 6 and 7 show a muller installation in which the automatic controls and resin measuring apparatus are seen.

Foundrymen should examine their own particular needs, select a mixer with the proper capacity and be sure that screening and conveying equipment do the job for which they were intended.

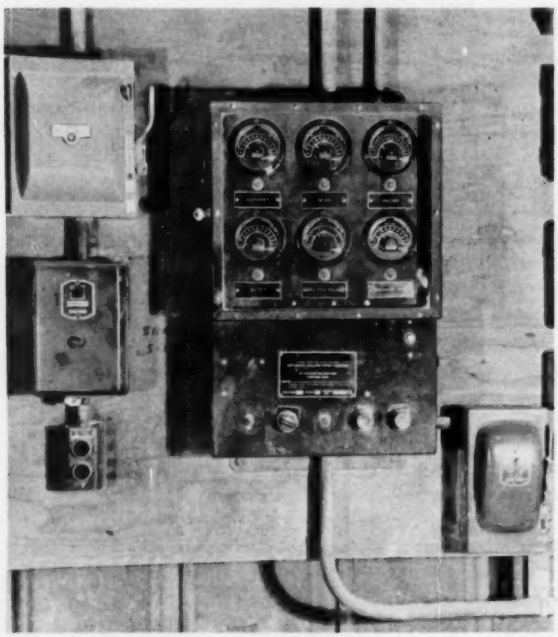


Fig. 6 — Automatic control board.

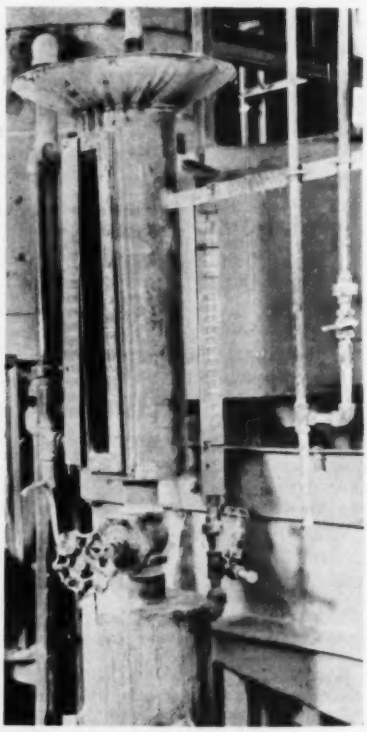


Fig. 7 — Method of liquid resin addition.

HEAT TREATMENT OF Mn-V-Mo AGE-HARDENABLE AUSTENITIC STEEL

by N. C. Howells and E. A. Lange

ABSTRACT

The age-hardening characteristics of Mn-V-Mo austenitic steels have been determined and depend upon the temperature of the solution treatment. Optimum conditions for developing the full age-hardening potential of an alloy are ½-hr at 2100 F followed by a water quench. Subsequent aging treatments required for maximum hardness levels are: one hr at 1400 F, 6 hr at 1300 F, or 16 hr at 1200 F. An aging temperature of 1250 F is optimum for controlling the balance between yield strength and ductility. The yield strength of metal in the fully aged condition is directly proportional to Brinell hardness. Yield strengths range from 80,000 to 150,000 psi for the compositions investigated.

INTRODUCTION

This investigation concerned the two-stage heat treatment of a new family of age-hardenable austenitic steels for castings. The development of these age-hardenable, austenitic steels was initiated by the lack of nonmagnetic alloys with high yield strengths for structural applications aboard minesweepers, equipment used in the proximity of magnetic instrumentation and structures operating in strong electromagnetic fields.

It was previously reported that an austenitic steel using manganese as the principal element for stabilizing austenite could be substantially hardened by a two-stage heat treatment, i.e., a high temperature solution treatment followed by a water quench, and then an aging treatment at an intermediate temperature.*,† The key feature in the development of these alloys was the high solubility of vanadium and molybdenum carbides at a high solution temperature (2100 F), and the re-precipitation of these carbides throughout the matrix during an aging treatment at 1300 F.

It was reported that chromium carbides have the objectionable tendency to form at grain boundaries. Thus, for casting alloys chromium contents must be limited to prevent a brittle condition in the hardened state. The general composition range of alloys that could be age-hardened to high strength levels and maintain a magnetic permeability less than 1.2 was as follows:

C, %	Mn, %	Ni, %	V, %	Mo,%	Cr, %
0.25-0.6	14-18	2-4	0.25-0.9	0-3.5	0-2.5

The heat treatments used in the previous investigations incorporated a nominal solution treatment of one hr at 2100 F. Because of the importance of the heat treatment for developing the full potential of mechanical properties, additional studies were conducted concerning the effects of the variables, time and temperature, of the solution treatment on the hardness after aging and the relationship between hardness and yield strength. It was the aim of this investigation to provide an optimum solution treatment, and a practical guide for determining the strength potential of an alloy by establishing a hardness-yield strength relationship.

PROCEDURE

Details of the foundry practice used in melting and casting these reactive, high manganese alloys were presented in a previous report,† and are briefly reviewed here. The base melting stock (armco iron) was melted in a 350 lb, basic-lined induction furnace. The melting practice incorporated a carbon boil and protective covers of argon gas and basic slag to minimize oxidation and hydrogen contamination. The molten metal was cast into molds of zircon sand con-

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*Lange, E. A., Howells, N. C. and Bukowski, A., "Cast Age-Hardenable Austenitic Steels," AFS TRANSACTIONS, *vol. 66*, p. 519 (1958).

†Howells, N. C. and Lange, E. A., "Foundry Characteristics of Mn-V-Mo Age-Hardening Austenitic Steel," AFS TRANSACTIONS, *vol. 67*, p. 517 (1959).

taining 10 per cent silica sand and one per cent core oil, to prevent a reaction with the mold material and inhibit the formation of a strong manganese oxide film; both can cause severe surface imperfections.

The principal casting shape was a 4x6x1-in. plate, and samples for tensile testing were taken from edge sections to the plates. Individual 1x1x¼-in. specimens for hardness tests were cut from random sections of the plates.

The metal specimens were rapidly heated to solution temperatures, 1900 F to 2200 F, in a barium chloride salt furnace which minimized surface oxidation. After the holding period the specimens were quenched in water. An air draw furnace was used for aging periods of 4 hr or more. An intermediate temperature salt furnace was used for aging periods less than 4 hr. The specimens were quenched in oil from the aging temperatures, 1200 F to 1400 F. Temperature control during the solution treatment and the aging treatment was ±10 F and ±5 F, respectively.

SOLUTION TREATMENT

The microstructure of Mn-V-Mo alloys in the as-cast condition is essentially an austenitic matrix with massive carbides at interdendritic and grain boundary positions. It is the purpose of the solution treatment to dissolve the carbides and then rapidly quench this homogeneous structure to a supersaturated condition. The hardness level in the as-cast condition ranges from 200-260 Brinell hardness, depending upon the amount of carbide forming elements in a specific alloy.

BRINELL HARDNESS OF MN-V-MO AUSTENITIC STEEL* GIVEN VARIOUS SOLUTION TREATMENTS AND AGED FOR 4 HR AT 1400 F

	Temperature of Solution Treatment, F			
Time, Min	1900	2000	2100	2200
	Brinell Hardness			
8	—	—	262	302
15	—	255	—	302
30	269	241	277	285
60	248	241	—	—
120	241	—	—	—

*Composition: 0.32% C, 16.3% Mn, 3.4% Ni, 0.14% Si, 0.71% V, 1.45% Mo. Hardness as Cast: 201 BHN

The elimination of the massive carbides during the solution treatment decreases the hardness level to the range of 150-200 Brinell hardness, and in this softened condition the metal is difficult to machine due to the high ductility of the base material and the sensitivity of the material to work harden.

The time required to reach an essential equilibrium status at solution temperatures was determined by a comparison of the hardness attained with a subsequent aging treatment of 4 hr at 1400 F. A comparison of hardness values in the fully aged condition provides a more sensitive test method than a comparison of hardness values in the solution treated condition before aging.

In the table are listed the hardness values for samples of alloy 17 that had been fully aged after solution treatments at 1900, 2000, 2100, and 2200 F for time periods of 8, 15, 30 60 and 120 min. The apparent slight decrease in hardness with increased time for some of the solution temperatures was probably due to random scatter since an improved solution condition would be reflected as an increase in hardness. Equilibrium conditions were essentially achieved shortly after the temperature of the specimen had reached the furnace temperature, since no significant increase in hardness was observed as a result of extending the time of the solution treatment.

The shortest time periods investigated for the four solution temperatures were as follows:

Solution temperature, F	1900	2000	2100	2200
Minimum holding time for solution treatment, min	30	15	8	8

Although the cast structures of these alloys are highly segregated and complete homogeniety is not achieved with any solution treatment, a pseudo-equilibrium state is attained within practical limits of time. This is further illustrated by the data in Fig. 1.

In Fig. 1, the 1300 F aging characteristics of alloy 17 are shown after the following three different solution treatments: ½-hr at 2100 F, 2 hr at 1900 F and a double solution treatment of ½-hr at 2100 F followed by 2 hr at 1900 F. A substantial increase in the response to the aging treatment with the use of the higher temperature (2100 F) is apparent. A difference of 90 Brinell hardness can be noted at the 4 hr aging period. The improved aging characteristic from the 2100 F solution treatment was lost, however, when the metal was given a second solution treatment at 1900 F.

The aging characteristic after the double solution treatment was identical to the aging characteristic after the single solution treatment at 1900 F. This behavior supports the previous statements that a pseudo-equilibrium condition is attained in a relatively short time at solution temperatures. Although the times at solution temperature for data in Fig. 1 are longer than the minimum times in the previous discussion, they are within practical limits. It should be pointed out, however, that the metal used in these experiments had solidified in a one in. section, and metal with a greater degree of segregation from a slower rate of solidification may require a longer solution treatment to attain an equilibrium condition.

The following time periods for solution treatment were considered to be on the safe side for their corresponding temperature, and were adopted for all of the experiments concerning the effect of solution temperature on aging characteristics:

Solution temperature, F	1900	2000	2100	2200
Time at solution temperature, min	30	15	8	8

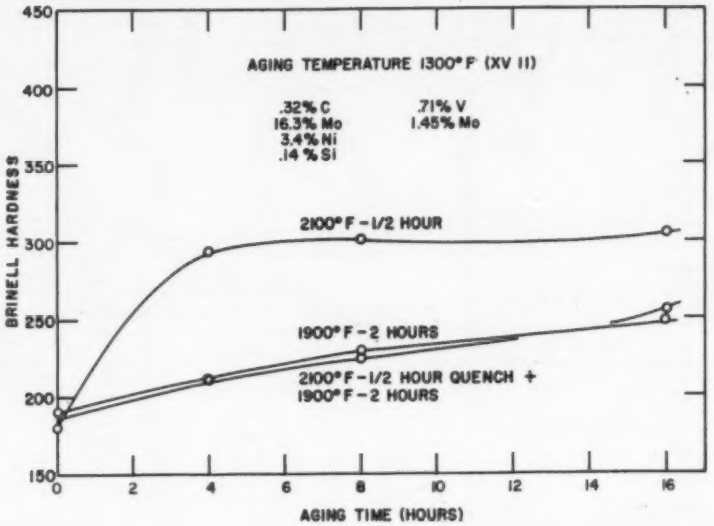


Fig. 1 — Comparison of age hardening characteristics of a Mn-V-Mo alloy after three different solution treatments. The age hardening characteristics following the double solution treatment (2100 and 1900 F) is identical to that for the single treatment at the final temperature (1900 F).

The preceding experiments concerning the optimum time for solution treatment necessarily involved the temperature variable, and a preview of the effect of the solution temperature on the characteristic age hardness curve was presented in Fig. 1. A more complete picture of the effect of solution temperature is presented in Figs. 2 and 3 where the 1300 F and 1400 F age hardness curves of alloy 17 are shown for solution treatments at 1900, 2000, 2100 and 2200 F.

Alloy 17 has a nominal composition and the effect of solution temperature on the aging characteristics as shown in Figs. 2 and 3 are typical for all alloys in this system. Increasing the solution temperature from 1900 F to 2200 F substantially increases the hardness attained for any specific aging treatment. However, the improvement in aging characteristics with increasing solution temperature was most pronounced between the temperatures of 2000 F and 2100 F, and the benefits obtained from higher temperatures (2200 F) are of doubtful significance. It is concluded that 2100 F, which was initially selected for preliminary heat treatments, is an optimum solution temperature for these age-hardenable Mn-V-Mo alloys.

AGING TREATMENT

Although all castings should be given an optimum solution treatment, it may be desirable for some applications to age harden for less than maximum hardness or yield strength. Since surface oxidation is not a problem at aging temperatures, the aging temperature can be adjusted to extend the time of the aging treatment and thus permit precise control of mechanical properties and increase ductility.

At 1400 F the hardening reaction proceeds rapidly, and maximum hardness was attained in the relatively short time of one hr (Fig. 4) which is too short for proper control of mechanical properties particularly

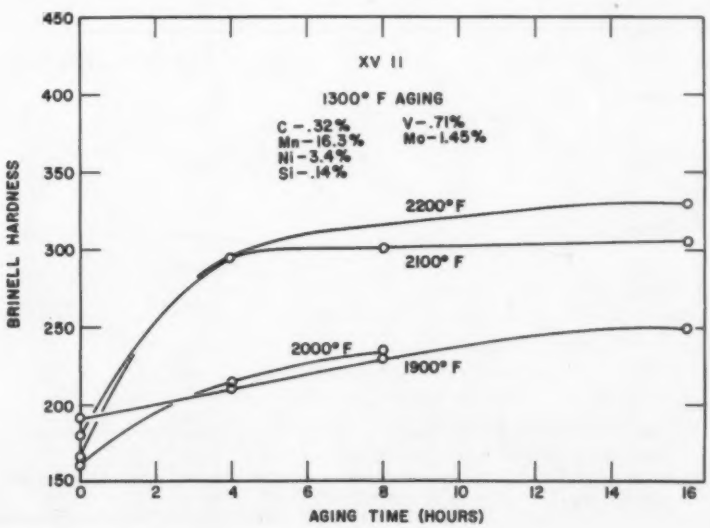


Fig. 2 — Temperature of solution treatment effect on the 1300 F aging characteristics of Mn-V-Mo austenitic steel.

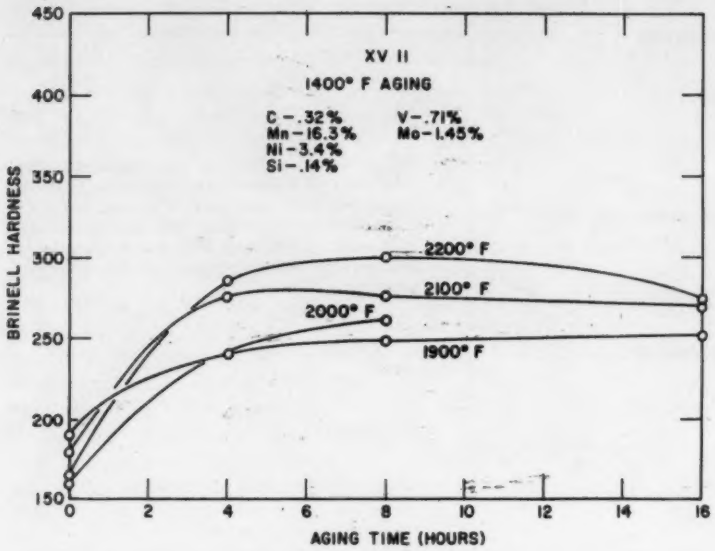


Fig. 3 — Temperature of solution treatment effect on the 1400 F aging characteristics of Mn-V-Mo austenitic steel.

when the castings have various section thicknesses. Figure 5 illustrates the typical relationship between hardness and the aging variables, time and temperature. Hardness for a particular aging treatment will, of course, vary with the composition of the alloy, but the maximum hardness for aging temperatures of 1300 F and 1200 F is attained in 4-8 hr and 16 hr, respectively.

The influence of the aging conditions on the tensile properties of the same alloy is presented in Fig. 6. An aging treatment of 8 hr at 1300 F developed the highest yield strength, 110,000 psi with 12 per cent elongation, but a yield strength of 92,000 psi was developed in 16 hr at 1200 F with 31 per cent elongation. On the basis of these data, an intermediate temperature (1250 F) would appear to be optimum for aging to a controlled balance between yield strength and ductility.

The hardness test does not distinguish between a brittle or a ductile microstructure, but hardness values can serve as a useful guide for predicting the yield strengths of alloys that have been given comparable heat treatments and have the same basic microstructure (Figs. 5 and 6).

The relationship between yield strength and Brinell hardness for age-hardenable austenitic steels, with compositions in the range covered in this study and age hardened at 1300 F for 8 hr or 1200 F for 16 hr, is presented in Fig. 7. With these conditions for aging, the yield strength was directly proportional to the hardness. Although the tensile strength is dependent upon ductility, the yield/tensile ratio is approximately 0.75 for metal in the fully aged condition. The overall yield strength range, 80,000 psi to 150,000 psi, presented in Fig. 7, demonstrates a flexibility in mechanical properties that is rather unique

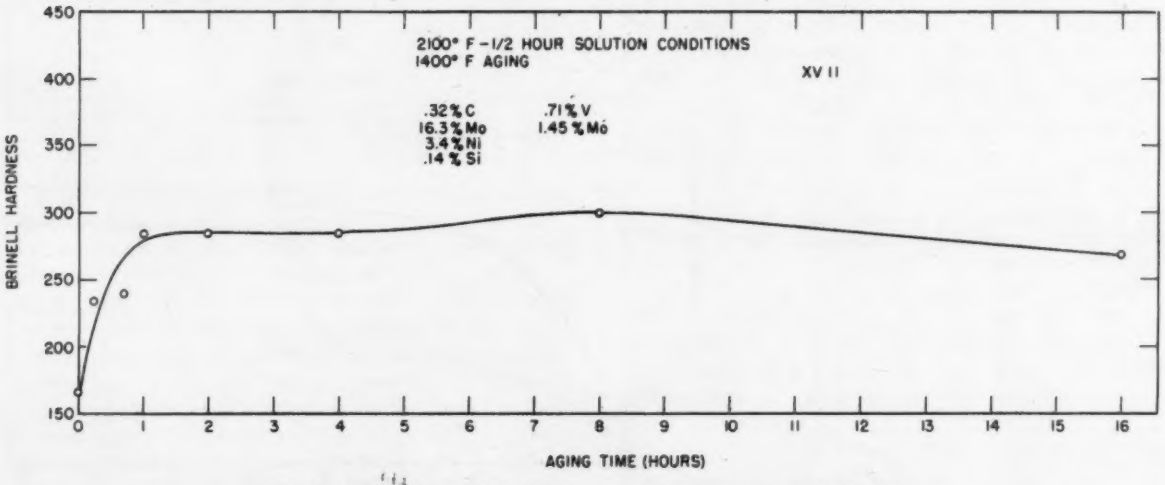


Fig. 4 — Rapid increase in hardness at aging temperature of 1400 F.

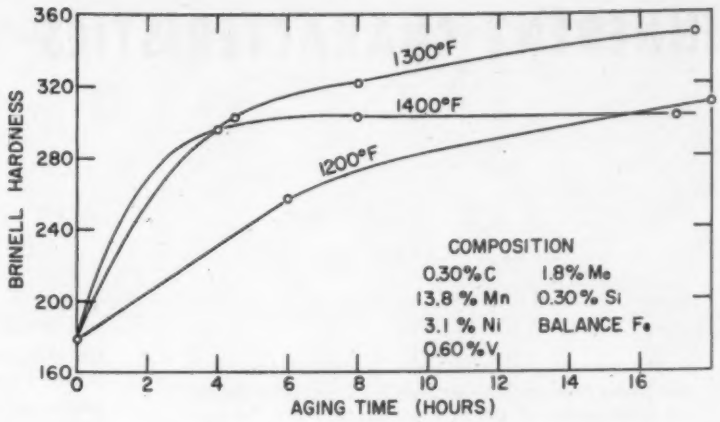


Fig. 5 — Time and temperature during aging treatment effect on the hardness of a precipitation hardening austenitic steel.

for austenitic alloys. This flexibility should contribute to the application of these alloys for service conditions in addition to those with a restriction for magnetic permeability.

SUMMARY

A solution heat treatment at a minimum temperature of 2100 F is required to fully develop the age hardening characteristics of Mn-V-Mo austenitic steels in the composition range of 0.25-0.6 per cent C, 14-18 per cent Mn, 0.25-0.9 per cent V, 0-3.5 per cent Mo and 0-2.5 per cent Cr. Solution temperatures above 2100 F do not significantly improve the age hardening characteristics. Extension of the time of treatment at 2000 F does not compensate for the lower temperature. The optimum conditions for the solution treatment are 30 min at 2100 F followed by a water quench.

Full hardness was attained within one hr at 1400 F, but a slightly higher hardness was attained in 6 to 8 hr at 1300 F or 16 hr at 2100 F. Limited tensile tests with an alloy having a composition with an intermediate hardening potential, 0.3 per cent C, 0.6 per cent V and 1.8 per cent Mo, developed tensile properties of 145,000 psi T.S., 110,000 psi Y.S. and 12 per cent elongation with an aging treatment of 8 hr at 1300 F. In the fully aged condition (8 hr at 1300 F or 16 hr at 1200 F) the yield strength of the Mn-V-Mo alloys was directly proportional to the hardness, and yield strengths ranging from 80,000 psi to 150,000 psi were obtained for alloys within the composition limits stated above.

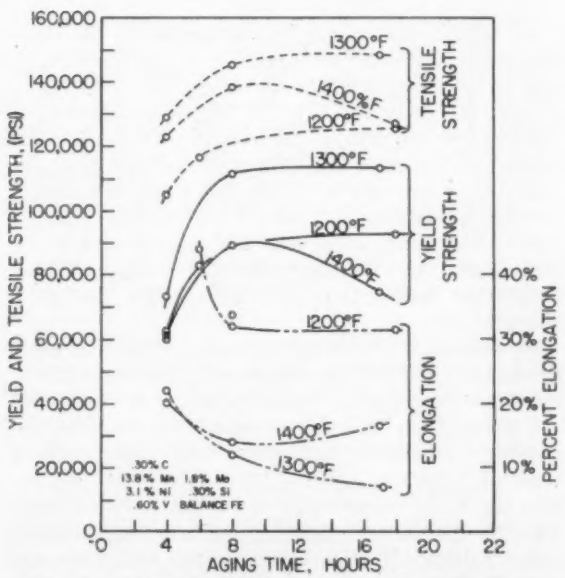


Fig. 6 — Aging conditions influence on tensile properties of a precipitation hardening austenitic steel.

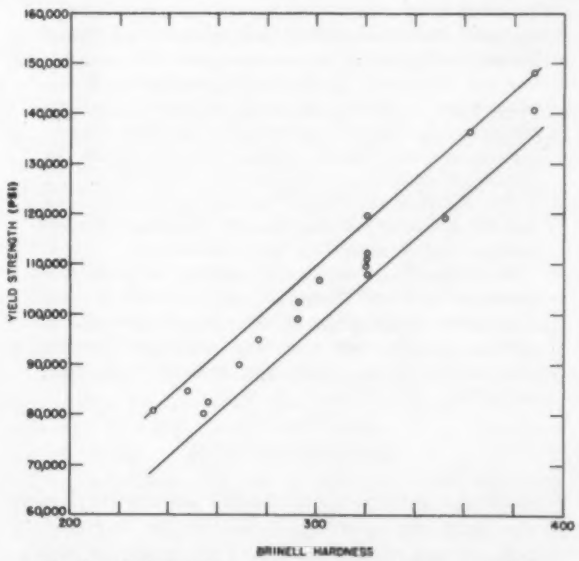


Fig. 7 — Relationship between 0.2 per cent yield strength and Brinell hardness for Mn-V-Mo austenitic alloys in the composition range of 0.25-0.6 per cent C, 14-18 per cent Mn, 2-4 per cent Ni, 0.25-0.9 per cent V, 0-3.5 per cent Mo and 0-2.5 per cent Cr. Heat treatment: solution treatment ½ hr at 2100 F, water quench. Aging treatments: 8 hr at 1300 F, oil quench; or 16 hr at 1200 F, oil quench.

CAST 70/30 CUPRO-NICKEL INHERENT CHARACTERISTICS

by B. F. Shepherd

ABSTRACT

The increasing attention given to 70/30 cupro-nickel for pump castings with sections 2 in. and over led to an investigation of the behavior characteristics of this alloy. Properties were found to be markedly affected by silicon content. The silicon level required to meet the tensile properties of MIL-C20159 seriously affected weldability. Satisfactory weldability was obtained with low silicon contents but did not produce the required tensile properties.

The use of columbium in conjunction with silicon created a new weldable alloy with mechanical properties much higher than obtained with silicon alone. The amount of silicon and columbium required is dependent upon the strength-ductility level desired. At 40,000 psi yield strength silicon and columbium should each approximate 0.45 per cent. Weldability can be obtained at higher silicon contents with Si<Cb, and higher strength at lower silicon levels with Cb>Si.

Mechanical properties are markedly affected by cooling rate in the mold. This is illustrated by tests from actual castings and test bars of varying mass. While the 70/30 cast cupro-nickel alloy is not considered heat treatable, it is found that the mechanical properties can be substantially increased by homogenizing heat treatments. The effects of time, temperature and composition are discussed. The inherent potentiality of any composition is realized by homogenization. This heat treatment can be used to neutralize the differences in cooling rate existing in castings, and to realize the maximum strength potential of any composition.

The ductility and Brinell hardness are shown to be directly related to the yield strength regardless of composition and/or acceptable heat treatments.

Production heats have been made in induction and direct arc furnaces. Direct arc heats of 6300 lb have been melted utilizing up to 100 per cent returns. The melting practice and analytical equipment enables close control of the composition, particularly the iron, columbium and silicon.

INTRODUCTION

Increasing service requirements necessitate higher pump pressures, making it imperative to produce sound castings with integrity. The weight of equipment is important so that thinner pump sections which can be produced by higher strength materials are advantageous to the designer as well as the foundryman. Corrosion resistance to sea and brackish water, compatability with wrought components, antifouling and freedom from pitting under varying water velocities have directed the attention of the pump designer to the use of 70/30 cupro-nickel castings.

Thick wall sections of bronze pump castings are difficult to produce hydrostatically sound, particularly for high pressures. Bronzes with wide freezing ranges such as Navy *M* and *G* have a "pasty" solidification, an equiaxed crystal structure and dispersed porosity. Heavy sections in these bronzes are difficult to feed and produce free from porosity, which is readily exposed on machined areas or hydrostatic test.

If this porosity is classified as microporosity by radiographic standards, impregnation can be used to prevent leakage. Any subsequent welding operation, however, will destroy the integrity of the impregnated area. The difficulty of welding *M* and *G* bronzes limits the ability to repair foundry defects.

Literature Review

An exploration was started to determine the characteristics of the 70/30 cupro-nickel and its application to high pressure pumps using MIL-C-20159 as a basic specification. There is little information in the literature regarding the founding of this bronze. Kihlgren[1] discussed the effects of melting practices and various elements upon castability and mechanical properties. He stated—"I do not believe that a simple cupro-nickel containing 0.25 per cent Si and 1 per cent Mn . . . . . is inherently able to develop over 55,000 psi tensile strength and 20,000 psi yield strength."

In discussion of the above paper, J. Curran mentioned the extreme variation often encountered in mechanical properties. "Two heats of almost identical composition may be far apart in strength and ductility." Kihlgren attributed these differences to residual elements. Curran also stated that he felt that the Navy specification of 32,000 psi yield point was criticizable, and 25,000 psi was a more realistic value. Kihlgren thought this point was well taken and that 32,000 psi yield strength was a marginal value with 0.50 per cent Si and 0.70 per cent Fe (Table 1).

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(Patent applications are pending covering this material and process of heat treatment.)

60-42

TABLE 1 — SUMMARY OF U.S.N. SPECIFICATIONS

	Cu	Sn	Zn	Pb	Ni	Fe	Mn	Si	Al	P	G	Ti
"M" Metal	86	5.5	3.0	1.0	1.0x	0.25x				0.05x		
MIL-B-16541	89	6.5	5.0	2.0								
"G" Metal	86	7.0	3.0	0.30x	1.0x	0.15x				0.05x		
MIL-B-16576	89	9.0	5.0									
70/30 Cu-Ni	Rem.	—	1.0x	0.03x	28.0	0.25	1.25x	0.70x	0.50x		0.15x	0.25x
MIL-C-20159					32.0	0.60						
Proposed Revision						0.40	1.50x					
						1.00						

	Yield Str.	Tensile Str.	Elong., %
"M" Metal	16,000*	34,000	22
"G" Metal	18,000*	40,000	20
70/30 Cu Ni	32,000**	60,000	20
Proposed Revision	32,000	60,000	15

*Ref. A.S.T.M. B143 — 0.5% elongation under load.
**Yield Point.

SILICON EFFECT

Experimental heats were made in the author's company's producton foundry using 600 lb and 1000 lb basic-lined induction furnaces, initially using the practices proposed by Kihlgren. The results showing the effect of silicon support Kihlgren's data which have been reproduced in Fig. 1, and upon which the new values are superimposed.

The inability to meet the United States Navy specification supported the contentions of Kihlgren and Curran. In addition, it was found that the silicon levels necessary to increase the yield strength seriously affected weldability. The ability to repair castings by welding is a commercial necessity for any metal. Iron could not be used to increase the yield strength within the limitation of 0.60 per cent maximum iron of the U.S.N. specification. It was found later that higher iron did not materially influence the yield strength in the lower silicon range.

Discussions with previous manufacturers of 70/30 cupro-nickel while helpful did not produce any directly applicable data. The Bureau of Ships, also studying the problem, had apparently improved the physicals by use of iron and manganese and revised the MIL specification, raising manganese from 1.25 to 1.50 per cent, iron from 0.60 to 1.00 per cent and reducing elongation from 20 to 15 per cent.

The increase in maximum permissible iron was of considerable help initially in utilizing larger percentages of gates and risers in the charge make-up, but means were found to control the iron content. The above modifications of manganese and elongation were unnecessary and not utilized in our practice. However, it is necessary to have about twice as much manganese as silicon at lower silicon levels in order to reduce the grain coarsening tendency of the silicon.

COLUMBIUM AND SILICON EFFECT

Columbium had been accepted by U.S.N., as indicated in Specification QQ-N-288-Comp. E (12/20/56) to provide weldability in monel metal. The International Nickel Co.[2] state that in general a 2 per cent

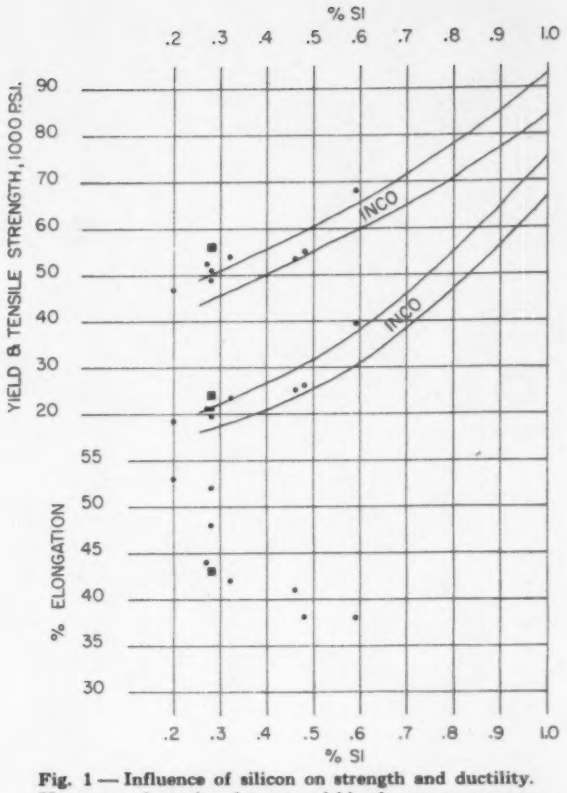


Fig. 1 — Influence of silicon on strength and ductility. Heats contain major elements within the per cent range of; Cu — 67.1-68.6; Ni — 29.1-30.7; Mn — 0.32-1.12; Fe — 0.41-0.95 (except one with 1.45 per cent, designated by dot inside the box); Cb — none.

columbium level will impart good weldability to Ni-Cu alloy castings containing up to 1½ per cent silicon. Although good results can be obtained with only one per cent columbium, a greater margin of safety exists at the 2 per cent level.

Initially, a master alloy containing nickel and 10 per cent columbium was made with 8 mesh x down, Fe-Cb (50-60 Cb, 25-30 Fe, 5-7 Si, 5-7 Ta) to insure better solubility of columbium in the heat. Later, means were found for adding the Fe-Cb direct to the melt.

It is obvious from Fig. 2 that the addition of columbium has enhanced the ability of silicon to increase the yield and tensile strength. In all compositions tested, the ductility and Brinell hardness were found to be a direct function of the yield strength, and are so plotted (Fig. 3). Yield strengths were determined at 0.5 per cent offset with a strain recorder for all tests.

The data from Fig. 18 of Kihlgren[1] are superimposed on Fig. 2 to show the definite and beneficial influence of the columbium. The 70/30 alloy with columbium becomes a new material with much improved mechanical characteristics.

This is particularly important as the casting design can be altered accordingly with reduction of sections, resulting in lighter castings where weight is important and for improved soundness.

The intensification effect of columbium in increas-

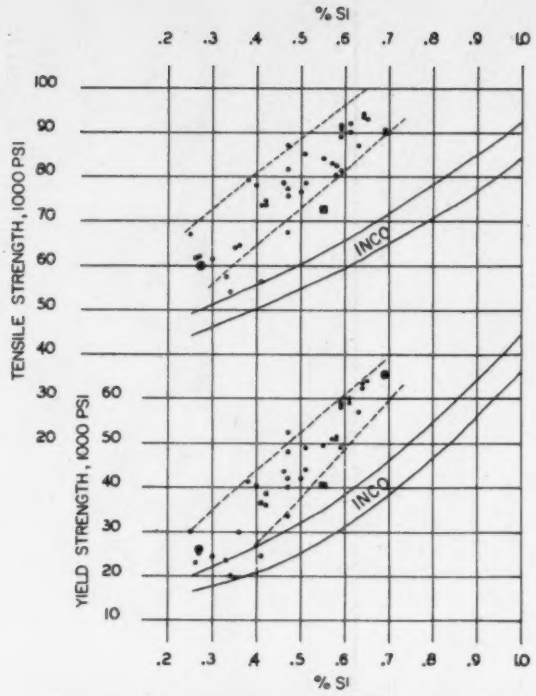


Fig. 2 — Influence of Si and Cb on strength of 70/30 cupro-nickel. Heats contain major elements within the per cent range of; Cu — 65.7-68.4; Ni — 28.8-31.6; Mn — 0.83-1.41; Fe — 0.50-0.94 (except one with 1.07 per cent designated by dot inside box); Cb — 0.33-0.83.

ing yield strength is indicated in Fig. 4. With low silicon content (less than 0.40 per cent approx.), columbium is necessary to meet the strength requirements. As the silicon is increased, columbium is necessary to make the material weldable.

COOLING RATE INFLUENCE ON TEST BAR PROPERTIES

The impatience to obtain mechanical results on experimental heats led to shaking out of the bars from the mold after approximately 20 min. The temperature of the test bars at this time was approximately 1400 F. Check tests made on bars allowed to cool for 2 hr (temperature approximately 500 F) before shaking out showed considerable increase in yield and tensile strength, and all subsequent test bars were

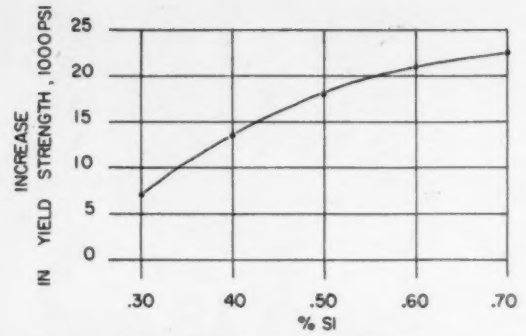


Fig. 4 — Influence of Cb on yield strength at various per cent Si levels.

	Yield Strength			
	Heats with Si Avg. values — Fig. 1	Heats with Si and Cb Avg. values — Fig. 2	Increase	
Si, %			psi	%
0.30	20,000	27,000	7,000	35.0
0.40	23,500	37,000	13,500	57.5
0.50	28,000	46,000	18,000	64.2
0.60	34,500	55,500	21,000	61.0
0.70	42,500	65,000	22,500	53.0

allowed to cool in the mold. The elongation and Brinell hardness again are altered in relation to the yield strength. The results on six heats are shown in Fig. 5.

This may explain some of the inconsistent behavior reported for this alloy. Inasmuch as it was probably caused by the mechanism of freezing of a solid solution (nickel and copper are completely soluble at all temperatures) heat treatments were used to homogenize the structure.

HOMOGENIZATION HEAT TREATMENT INFLUENCE

Test bars were heated in an electric furnace to various temperatures held for one hr at temperature and allowed to cool slowly to 500 F or lower. A startling increase in yield and tensile strength was obtained, as shown in Fig. 6, with composition as shown on Table 1A. Elongation and Brinell hardness again follow the change in yield strength except for homogenization at 1550 F, where the elongation was reduced disproportionally. The strengthening effect was noted as low as 900 F held 24 hr at tempera-

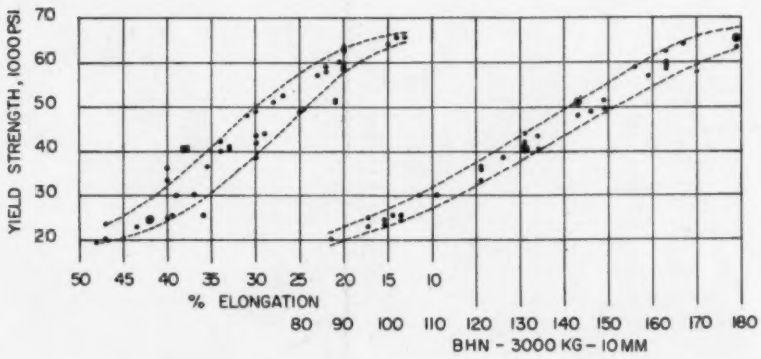


Fig. 3 — Relationship of ductility and hardness to yield strength of Cb 70/30 cupro-nickel. All heats contain major elements within the per cent ranges of; Cu — 65.7-68.4; Ni — 28.8-31.6; Mn — 0.83-1.41; Fe — 0.50-0.94 (except one with 1.07 per cent designated by dot inside box); Cb — 0.33-0.83.

TABLE 1A — CHEMICAL ANALYSIS

Ref. No.	Heat No.	Cu, %	Ni, %	Si, %	Cb, %	Mn, %	Fe, %
1	N546	Rem.	30.8	0.41	0.49	1.41	0.52
2	N547	Rem.	30.3	0.42	0.64	1.05	0.55
3	L99-2	Rem.	29.6	0.46	0.49	1.05	0.66
4	L99-3	Rem.	29.4	0.63	0.50	1.04	0.67
5	L99-4	Rem.	29.3	0.65	0.83	1.04	0.86
6	L99-1	Rem.	29.8	0.41	0.07	1.04	0.42
7	N642	Rem.	30.4	0.33	0.33	1.36	0.58
8	N643	Rem.	31.1	0.36	0.40	0.83	0.80
9	N609	Rem.	29.2	0.57	0.41	0.99	0.55
10	N610	Rem.	29.8	0.27	0.35	0.85	0.58
11	N611	Rem.	30.5	0.51	0.43	1.13	0.56
12	L362	Rem.	29.7	0.55	0.34	1.33	1.07

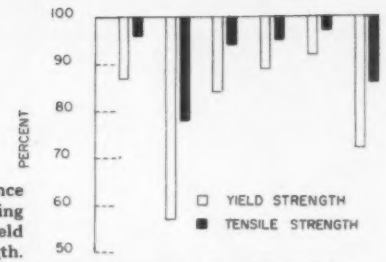


Fig. 5 — Influence of time of cooling in mold upon yield and tensile strength. Base of 100 per cent represents values obtained by orthodox cooling of more than 2 hr in the mold. Bars indicate per cent of damage produced by removing from mold in 20 min.

ture. Of the temperatures utilized the 1200 F temperature gave the best mechanical properties and was used for most of the tests.

Whenever the heating at temperature for one hr was followed by cooling in air, no change was observed in the strength. Whenever castings were homogenized in a large production furnace, the increase was greater than that obtained in the small laboratory furnace. Experiments were conducted to determine the effect of time at temperature and cooling rate, as shown in Fig. 7.

This behavior is unorthodox as it is generally assumed that thin sections of castings are structurally better than heavier sections. This must not be confused with the effect of mass upon soundness, and further discussion proceeds on the basis that all sections are sound. It would seem, therefore, that a

Heat No. —	L50	N548	L99-2	L99-3	L99-4	N643
Cu	rem	rem	rem	rem	rem	rem
Ni	28.9	30.6	29.6	29.4	29.3	31.1
Si	0.69	0.47	0.46	0.63	0.65	0.36
Cb	0.51	0.62	0.49	0.50	0.83	0.40
Mn	1.32	1.05	1.05	1.04	1.04	0.83
Fe	0.64	0.58	0.66	0.67	0.86	0.80
C	0.01	0.03	0.02	0.02	0.02	0.02

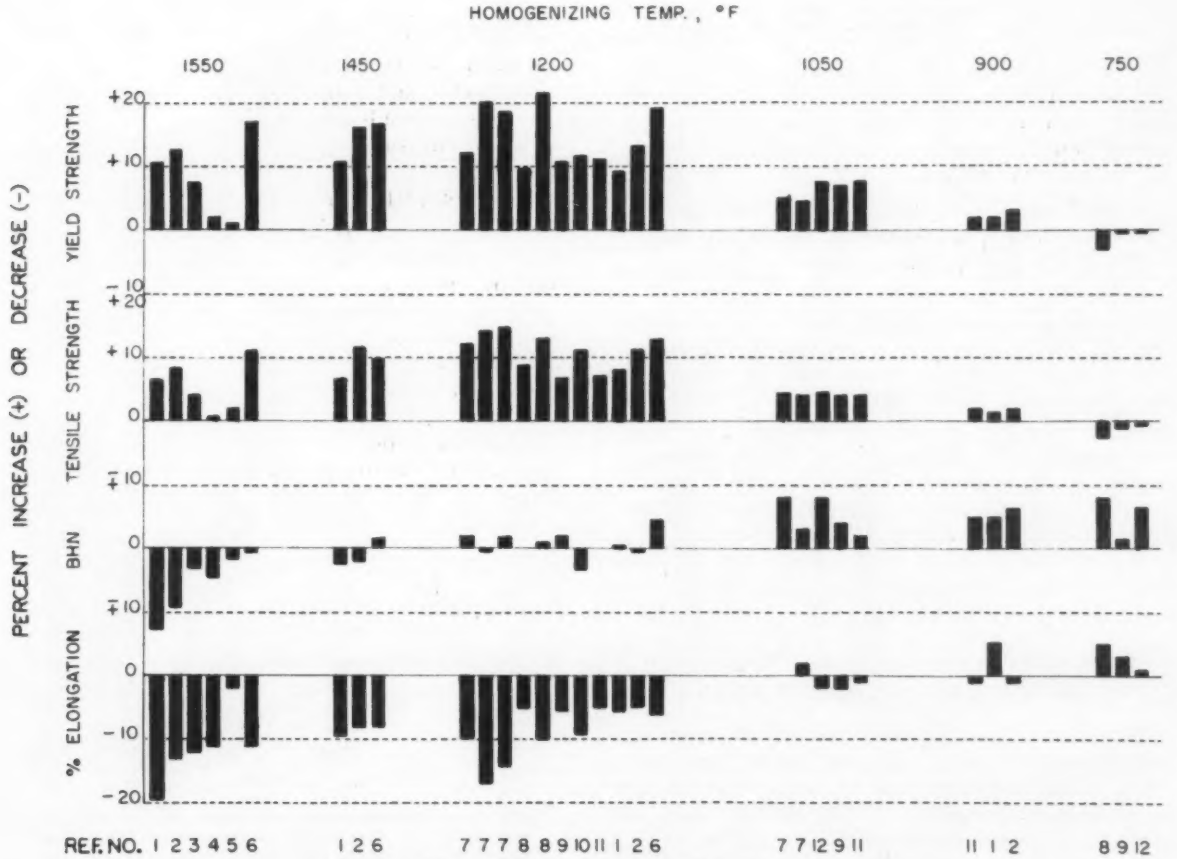


Fig. 6 — Homogenizing temperature influence on mechanical properties. Specimens furnace cooled to 500 F.

Test No.	Bar No.	Heat Treatment	Yield Str., psi 0.5 Offset	Tensile Str., psi	Elong., % in 2 in.	Bhn, 3000 Kg
L728-2	A	(1)	24500	61500	42.0	99
	B	(2)	32500	68000	33.0	118
	C	(3)	29000	65500	39.0	111
	D	(4)	34500	70000	36.0	121
L728-3	A	(1)	40500	78000	33.0	134
	B	(2)	45500	82000	24.0	137
	C	(3)	39000	77500	30.0	140
	D	(4)	45000	81500	26.0	152
L728-4	A	(1)	36000	73500	40.0	116
	B	(2)	43000	79000	35.0	143
	C	(3)	35000	73500	35.5	123
	D	(4)	48000	80000	28.0	143
L728-5	A	(1)	33500	67500	40.0	126
	B	(2)	46000	76000	29.0	137
	C	(3)	36000	68000	36.0	121
	D	(4)	46500	76000	31.0	149
L728-6	A	(1)	42000	76500	34.0	131
	B	(2)	49500	80000	23.0	143
	C	(3)	43000	76000	34.0	149
	D	(4)	50000	82500	29.0	159
L728-7	A	(1)	49000	85000	25.0	146
	B	(2)	54000	87500	21.0	156
	C	(3)	46500	83000	28.0	156
	D	(4)	54500	87000	20.0	167

NOTE — All bars cooled in mold for 2 hr min. prior to heat treatment.
(1) As-cast.
(2) Homogenized: 1200 F — 1 hr at temp. Furnace cool to 500 F.
(3) Special: 1200 F — 5 hr at temp. Cool in air.
(4) Homogenized: 1200 F — 5 hr at temp. Furnace cool to 500 F.

	CHEMICAL ANALYSIS, %					
Test No.	Cu	Ni	Si	Cb	Mn	Fe
L728-2	Rem.	31.0	0.30	0.44	1.06	0.60
L728-3	Rem.	31.0	0.40	0.79	1.04	0.83
L728-4	Rem.	31.4	0.42	0.59	1.14	0.73
L728-5	Rem.	31.6	0.47	0.34	1.07	0.50
L728-6	Rem.	31.2	0.50	0.59	1.06	0.64
L728-7	Rem.	30.3	0.51	0.83	1.04	0.84

Fig. 7 — Time at temperature and cooling rate effect on mechanical properties.

homogenization treatment can be applied to all castings of 70/30 cupro-nickel to realize the inherent potential strength of the composition and neutralize the effect caused by the quick cooling of the thinner sections.

Homogenization treatments at 1200 F were conducted on 12 heats with silicon from 0.27 to 0.57 per cent, and columbium from 0.33 to 0.83 per cent. Figure 8 shows the strength values (particularly yield strength) to be, or above, average level of the band obtained by the conventional as cast bars cooled in the mold, and shown in Fig. 2.

MASS AND COOLING RATE INFLUENCE ON MECHANICAL PROPERTIES

The effect of cooling rate upon tensile properties was pursued further by using test bars of larger mass, which alters the cooling rate. Separately cast test bars have many advantages, and "cast on" test bars are rarely used for non-ferrous metals. It may be well to restate the three main purposes for which castings are tested:[3]

1) Acceptance for delivery.
2) Control of foundry operations.
3) Research into casting process and properties of castings.

It is essential, therefore, that the test bar design be such as to guarantee consistency and represent the metal poured in the casting. The pouring temperature range should be that which will produce maximum consistency in the test bar properties. The relationship of these properties to those of the casting can only be determined by actual tests. The expected variation will depend upon the establishment and control of optimum conditions for pouring the castings. Uniformity of properties in any individual casting will be a function of its particular design and control of the casting operation.

Designing test bars is a popular metallurgical pastime especially for a new and slightly different composition. The results to be cited in Tables 2 to 7 inclusive are on accepted shapes of test bars, as shown on Fig. 9. Pouring temperatures were approximately 2500 F. Bars poured at lower temperatures were consistently defective due to the inability of the metal to free itself from entrapped air, as shown in Fig. 10. Gammagraphs were also taken of the various types of test coupons to determine shrinkage characteristics.

MASS OF TEST BAR EFFECT

The 1 in. Y-test bar, A.S.T.M. A339-55, was cast in dry sand and in a copper mold. All other bars were

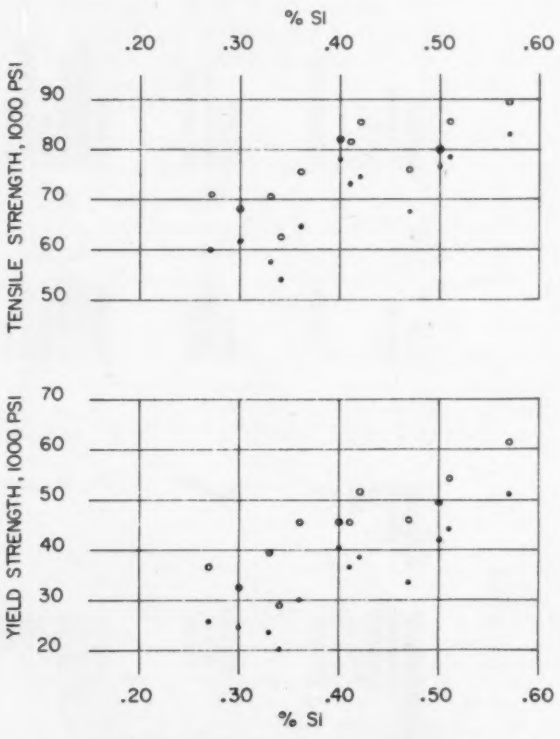


Fig. 8 — Homogenization influence on mechanical properties as a function of silicon content. Heats contain Cb — 0.33-0.83 per cent. Black dot — as-cast, cooled 2 hr in mold; circle — homogenized, cooled 2 hr in mold 1200 F, one hr at temp., F.C.

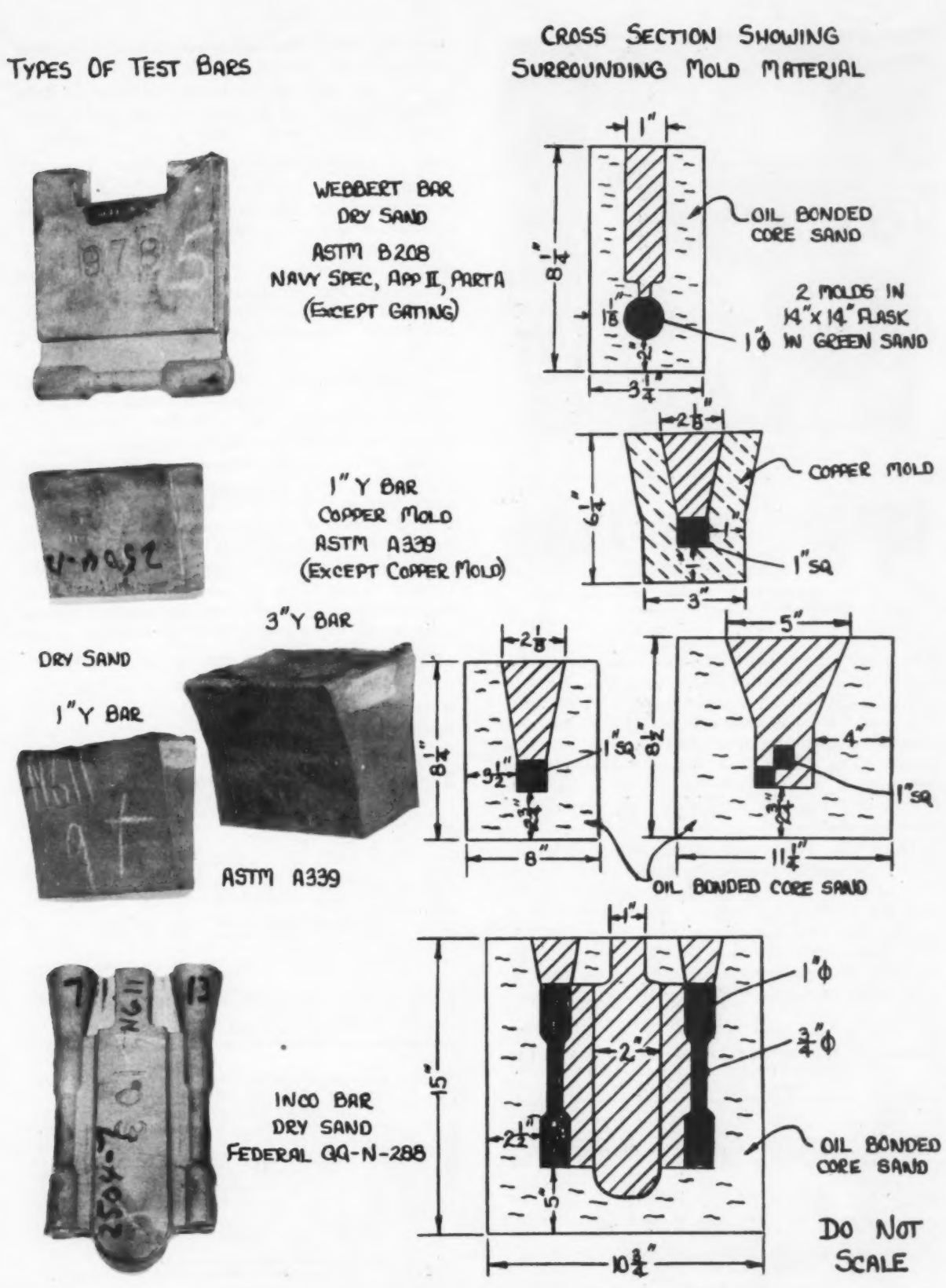


Fig. 9 — Types of test bars (left) and cross-section showing surrounding mold material (right).

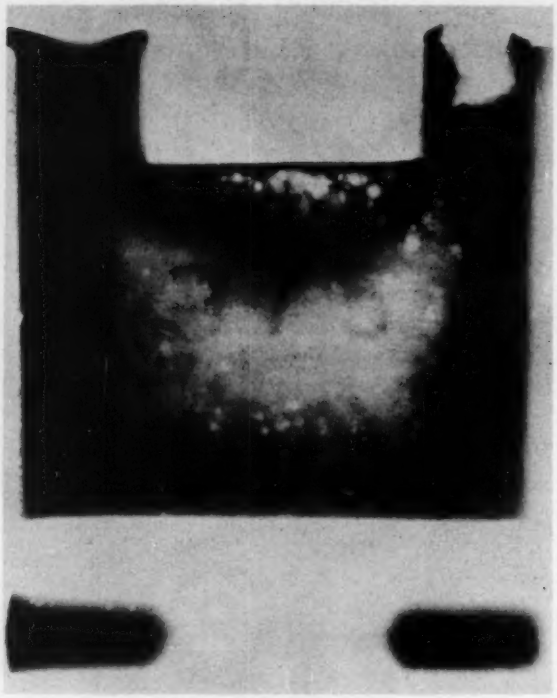


Fig. 10 — Gammagraph of Webbert bar poured below 2450 F. Note trapped air pockets in bar.

cast in dry sand. Unless otherwise indicated, all test bars in the data were threaded, 2 x 0.505 in., A.S.T.M. A370, machined from Webbert bars, A.S.T.M. B208. The 3 in. Y-bar was also A.S.T.M. A339-55, and tests were taken from the corner and center of the 3 in. section. The "Inco" bar was unsuitable because too many bars were defective due to trapped air. Whenever these bars were sound the results have been reported.

These tests again illustrate the effect of cooling rate of the test bar coupon. Even the slightly heavier mass of the 1 in. Y-bar produces higher properties than the Webbert bar, whereas the same bar cast in a copper mold has consistently lower values. The 3 in. Y-bar shows little difference between corner and center tests, and in many cases are higher than the 1 in. Y-bar properties. Wherever usable, the results from the "Inco" bar are lower than the Webbert bar.

The homogenization treatment eliminates the large differences caused by the initial cooling rate in these bars of different mass (Tables 2 to 7, inclusive).

CASTINGS PROPERTIES

Test bars were taken at locations of particular interest from two pump castings weighing 3950 lb (cleaned weight) (Fig. 11). One heat (N609) contained high silicon (0.57 per cent) and the other heat (N610) had low (0.27 per cent) silicon content (Table 8). The standard Webbert test bar from heat N610 was below specification for yield strength, but values after homogenization at 1200 F were satisfactory.

All the bars were taken from the 1½ to 1¾ in. thick sections near the outside, except Test N609-B-1 which was taken close to the inside surface. These tests were essentially equivalent.

Heat N610 with low silicon was self homogenizing because of the slow cooling rates obtained on this large casting. The values were considerably higher than the standard test bar and relatively unchanged by the homogenization heat treatment.

The values from N609 casting with high silicon were lowered slightly below the as-cast test bar value, and considerably under the homogenized test bar. Homogenization of the casting slightly lowered the values.

Mass Effect — 70/30 vs. "M" Metal

The effect of mass on *M* metal test bars was determined in a similar manner to that previously described for 70/30 (Fig. 9), with results shown in

TABLE 2 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR AND HEAT TREATMENT

Heat N609 Basic Direct Arc 55% Returns — 6300 lb	0.5% Yield Str.		Tensile Str.		Elong., %		Bhn, 3000 Kg	
	AC	Homo	AC	Homo	AC	Homo	AC	Homo
U.S.N. dry sand	51,000	61,500	83,000	89,500	28	22½	143	163
1 in. Y copper mold	45,500		80,000		35		137	
1 in. Y dry sand	55,500	61,000	83,500	87,000	24	20	163	167
3 in. Y dry sand corner	49,500	61,500	78,500	87,500	26	21	149	167
3 in. Y dry sand center	43,000	57,000	74,000	83,000	30	20	140	159

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P	Pb	Al	Ti	Zn
0.99	0.55	0.41	0.57	30.15	0.01	0.003	<0.020	0.016	0.005	0.05	<0.10

TABLE 3 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR AND HEAT TREATMENT

Heat N610 Basic Direct Arc 60% Returns — 6300 lb	0.5% Yield Str.		Tensile Str.		Elong., %		Bhn, 3000 Kg	
	AC	Homo	AC	Homo	AC	Homo	AC	Homo
U.S.N. dry sand	25,000	36,500	60,000	71,000	40	31	95.5	118
1 in. Y dry sand	26,000	34,500	61,000	69,000	39	31.5	101	121
3 in. Y dry sand corner	28,000	36,500	63,500	70,000	34	27	99.2	123
3 in. Y dry sand center	28,000	35,000	60,000	67,000	35	27	99.2	126

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P	Pb	Al	Ti	Zn
0.85	0.58	0.35	0.27	29.83	0.02	0.012	<0.020	0.00	0.004	0.05	<0.10

TABLE 4 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR AND HEAT TREATMENT

Heat N611 Basic Direct Arc 60% Returns — 6300 lb	0.5% Yield Str.		Tensile Str.		Elong., %		Bhn, 3000 Kg	
	AC	Homo	AC	Homo	AC	Homo	AC	Homo
U.S.N. dry sand	44,000	55,000	78,500	85,500	29	24	131	149
1 in. Y dry sand	47,500	55,500	78,000	85,000	27	25½	143	152
3 in. Y dry sand corner	36,500	53,500	71,500	84,500	37	26	123	156
3 in. Y dry sand center	33,500		67,000		33		116	

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P	Pb	Al	Ti	Zn
1.13	0.56	0.43	0.51	30.54	0.03	0.004	<0.020	0.004	0.006	0.05	<0.10

Table 9. Pouring temperature of 2050 F was determined with an immersion chromel-alumel thermocouple.

Young's Modulus — 70/30 vs. "M" Metal

Bars were suspended at their nodes and vibrated as free-free bars, the frequency measured and the modulus calculated from the dimensions, density and natural vibration frequency.

	Specific Gravity	P	f	E
"M" Metal	8.673	0.313	1055	13.3 x 10^6
70/30 Cu Ni	8.885	0.320	1292	20.5 x 10^6

METALLOGRAPHY

Studies of the structural changes produced by columbium at various silicon levels and cooling rates are being made. The effect of the so-called "homogenization" heat treatment is also being investigated metallographically. These studies will be reported at a later date.

WELDING

The weldability of a material is a relative term. Many metals are easily weldable by a variety of methods. Many others are weldable only with special

TABLE 5 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR AND HEAT TREATMENT

Heat N642 Basic Direct Arc 50% Returns — 6300 lb	0.5% Yield Str. AC	0.5% Yield Str. Homo	Tensile Str. AC	Tensile Str. Homo	Elong., % AC	Elong., % Homo	Bhn, 3000 Kg AC	Bhn, 3000 Kg Homo
U.S.N. dry sand 1 in. Y copper mold	23,500	39,500	57,500	70,500	47	33½	99.2	128
1 in. Y dry sand	26,000		61,500		39		103	
3 in. Y dry sand corner	25,000	30,500	58,500	64,000	40	34	87.1	123
center	24,500	30,500	59,500	64,000	41	33	103	114
Inco dry sand	26,000	30,500	59,000	64,000	36	31	103	116
Outside corners of runner 1¾ in. x 2¼ in. cross-section on parting line R.31,500	25,000	32,500	58,000	67,500	43	29	93.7	116
R1.31,500			62,000		35		111	
			62,500		35		116	

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P	Pb	Al	Ti	Sn	Zn
1.36	0.58	0.33	0.33	30.4	0.02	0.008	<0.020	0.007	0.005	<0.003	0.004	N.D.

TABLE 6 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR AND HEAT TREATMENT

Heat N643 Basic Direct Arc 75% Returns — 6300 lb	0.5% Yield Str. AC	0.5% Yield Str. Homo	Tensile Str. AC	Tensile Str. Homo	Elong., % AC	Elong., % Homo	Bhn, 3000 Kg AC	Bhn, 3000 Kg Homo
U.S.N. dry sand 1 in. Y copper mold	30,000	39,500	65,400	73,000	37	33	107	128
1 in. Y dry sand	28,500		64,000		40		111	
3 in. Y dry sand corner	32,500	40,000	68,500	75,500	37	34	114	131
center	37,000	38,500	71,500	73,000	31	30	123	131
Inco dry sand	34,500	37,500	66,000	70,500	30	31	121	131
Outside corners of runner 1¾ in. x 2¼ in. cross-section on parting line	28,500	37,500	64,000	72,500	43	37	107	131
	30,000		63,500		35		116	

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P	Pb	Al	Ti	Sn	Zn
0.83	0.80	0.40	0.36	31.1	0.02	0.011	<0.020	0.007	0.005	<0.003	0.004	N.D.

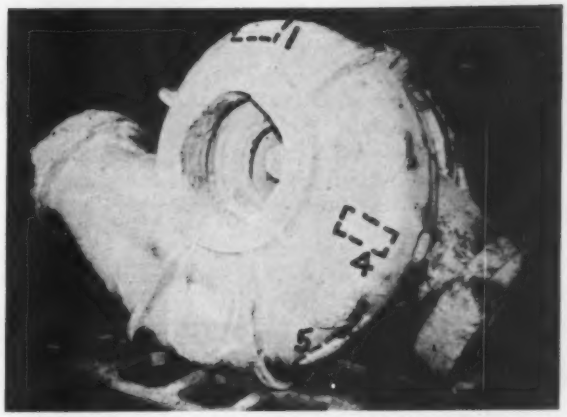


Fig. 11 — Location of test bars removed from castings.

TABLE 7 — MECHANICAL PROPERTIES VARIATION WITH TYPE OF TEST BAR

Heat L362 Induction Melt 100% Returns — 555 lb	0.5% Yield Str. AC	0.5% Yield Str. Homo	Tensile Str. AC	Tensile Str. Homo	Elong., % AC	Elong., % Homo	Bhn, 3000 Kg AC	Bhn, 3000 Kg Homo
U.S.N. dry sand 1 in. Y copper mold	40,500	—	72,500	—	38	—	131	—
1 in. Y dry sand	34,000	52,000	67,500	82,000	37	25	126	149
3 in. Y dry sand corner	41,500	47,500	71,500	74,000	33	30	143	137
center	40,500	44,500	69,500	68,500	31	24	137	131
Inco dry sand	41,500	46,500	71,000	74,000	29	24	134	143
	—	51,000	68,500	80,500	31	30	126	146

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.

Composition, %

Mn	Fe	Cb	Si	Ni	C	S	P
1.33	1.07	0.34	0.55	29.7	0.009	0.009	<0.020

TABLE 8 — MECHANICAL PROPERTIES OF TEST BARS FROM CASTINGS

Bar No.	Loc. No.	Section Thickness, in.	0.5% Yield Str. AC	0.5% Yield Str. Homo	Tensile Str. AC	Tensile Str. Homo	Elong., % AC	Elong., % Homo	Bhn, 3000 Kg AC	Bhn, 3000 Kg Homo
Heat 609, composition, %: Cu-68.3, Mn-0.99, Fe-0.55, Cb-0.41, Si-0.57										
Webbert Test Bars			51,000		83,000		28		143	
				61,500		89,500		22½		163
A	1	1¾*	46,500		75,500		19		156	
B	1	1¾**		46,500		78,000		19		156
G	4	1¼*	49,500		77,500		21		149	
H	4	1¼*		43,000		72,500		23		156
J	5	1¾*	46,000		76,000		17		152	
K	5	1¾*		45,500		73,500		15		149
Heat 610, composition, %: Cu-68.1, Mn-0.85, Fe-0.58, Cb-0.35, Si-0.27										
Webbert Test Bars			25,000		60,000		40		95.5	
				36,500		71,000		31		118
A	1	1¾*	38,000		65,500		22		118	
B	1	1¾*		38,000		68,000		26		128
G	4	1¼*	38,500		67,000		26		121	
H	4	1¼*		36,000		63,000		21		128
J	5	1¾*	36,000		64,000		23		121	
K	5	1¾*		35,500		64,500		24		123

AC — As-Cast.
Homo — Homogenized at 1200 F — 1 hr at temp. Furnace cool to 500 F.
*Close to outside surface.
**Close to inside surface.

TABLE 9 — MASS EFFECT ON "M" METAL

	Yield Str., 0.5% psi	Tensile Str., psi	Elong., %	Grain Type
Webbert bar dry sand	18,000	42,000	38	Medium
1 in. dry sand	18,500	36,500	22	Coarse
1 in. copper mold	23,500	51,500	45	Very fine
3 in. dry sand -corner	17,500	36,000	27	Medium
3 in. dry sand -center	Broke in machining threads			Dendritic (See Fig. 12)

Composition, %

Cu	Sn	Pb	Zn	Sb	P	S	Ni	Fe
87.42	5.89	1.46	4.25	0.047	0.005	0.040	0.87	0.092

attention. The shape and area to be welded is of considerable importance.

Minor and major welds have been generally defined in terms of section thickness and area. Many parts are assembled by welding with other castings. Qualified operators are required in many cases to produce welds of satisfactory quality. Quality is judged in many ways from visual freedom from voids to intensive dye penetrant, magnetic particle and/or radiographic inspection to various quality classifications.

The welding rod in many cases is selected on basis of ease of welding and many times required to produce a weld having composition and strength compatible with the casting. The need for stress relief or heat treating after welding affects the end quality and therefore the weldability.

Many types of tests are used to evaluate weldability, and, unfortunately, are related to and dependent upon other characteristics. In the case of 70/30 cupro-nickel, the material can be rated on the ability to electrically weld repair foundry defects falling in the "minor" classification without causing cracks to form in or around the weld.

The U.S.N. QPL list for MIL-E-19323 (1/31/58) welding rod lists approved rods for 70/30 cupro-nickel which are weldable materials, but are not expected to produce strengths equal to the requirements for the casting, as indicated in Par. 3.5.3.3.1—"Tensile strength of weld metal should be 50,000 psi." It is obvious that use of such materials for "through section" welds reduces the strength in these sections, and such welds should only be made with due regard for this feature.

A fully restrained weld was made on the Webbert bar by filling a 3/8-in. deep x 3/4-in. wide x 2 3/8-in. long sled runner type groove with 5 to 6 passes of 5/32-in. A.W.S. ECu Ni weld rod at 140 amps. DC, reverse polarity. Welding was started at ambient temperature and was continuous, i.e., no attempt made to control interpass temperature.

A slab approximately 3/8-in. thick was cut from each plate, as shown in Fig. 13. A similar slab was bent unwelded. In most cases, the ductility of the base material was high enough to permit 180 degree bends, as shown in Fig. 14. Where yield strength is above approximately 55,000 psi, the base material cracked at about 45 degrees, the base material of the welded slab cracking in a similar fashion. Typical weld tests are shown in Fig. 14. The composition and physical tests of these heats are listed in Table 10.

None of the weld tests show any internal or surface cracks as welded.

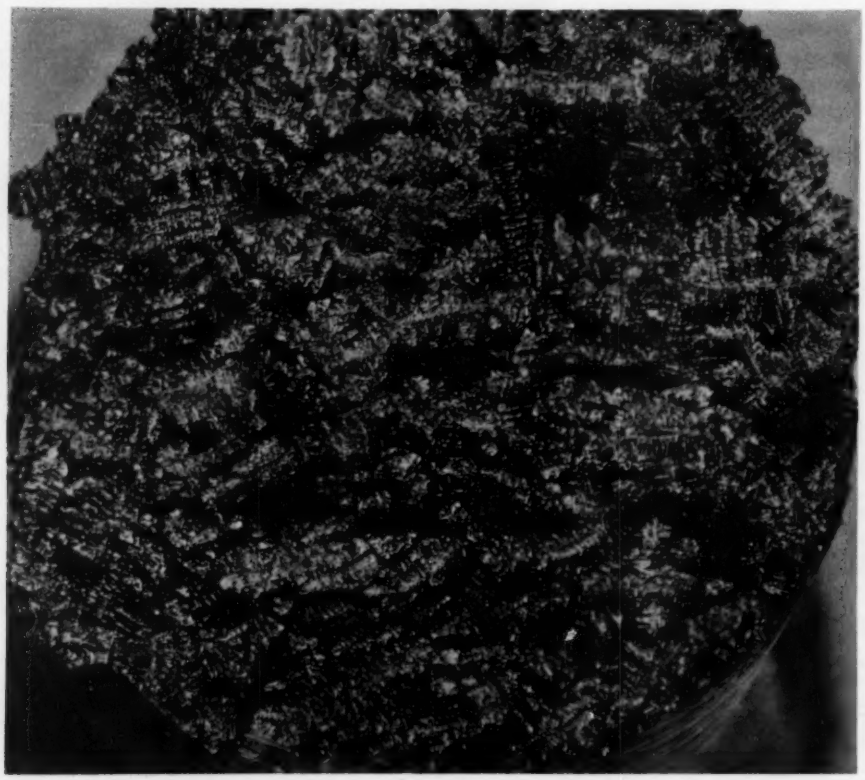


Fig. 12 — Fracture of tensile test bar taken from center of 3 in. Y-block. "M" metal. 10 ×.

TABLE 10 — COMPOSITION AND PHYSICAL TESTS

Heat No.	Composition, % Ni	Mn	Fe	Cb	Si	Yield Str.	Tensile Str.	Elong., %
N610-4	29.8	0.85	0.58	0.35	0.27	25,500	60,000	39½
N642-8	30.4	1.35	0.57	0.33	0.33	23,500	57,500	47
N643-8	31.1	0.83	0.80	0.40	0.36	30,000	64,500	37
K485-3	29.3	1.17	0.79	0.77	0.38	41,000	79,000	33
N546	30.8	1.41	0.52	5.49	0.41	36,500	73,500	35½
N547	30.3	1.05	0.55	0.64	0.42	38,500	74,500	30
N611-1	29.6	1.13	0.56	0.43	0.51	44,000	78,500	29
K695	30.3	1.10	0.81	0.68	0.55	49,500	84,000	24½
N609-2	29.2	0.99	0.55	0.41	0.57	51,000	83,000	28
N99-4*	29.3	1.04	0.86	0.83	0.65	60,000	93,000	15
N50-2*	28.9	1.32	0.64	0.51	0.69	65,500	90,500	13½

*Bent 45 degrees before crack appeared. Heats of this Si level without Cb could not be welded without cracking during welding even with preheat and/or interpass control.

All other tests show no cracks at 180 degrees bend.

ALL WELD METAL TESTS

All weld 0.505 in. test bars were machined from groove welds with groove length 6 in. thickness ¾-in. beveled sides 30 degrees (60 degrees included angle), root opening ½-in. and face opening 1½-in. The electrode was $\frac{3}{16}$-in.* used at 180 amps., direct current reversed polarity. The groove was completed with 14 passes with welding started cold and finished with continuous welding.

ALL WELD METAL DEPOSIT TENSILE PROPERTIES

	Yield Str., 0.5% Offset	Tensile Str.	Elong. % in 2 in.	Bhn
As welded	25,500	51,500	49	85.5
1200 F Homogenization	26,000	52,000	46	92

Chemical analysis of all weld metal deposit, %

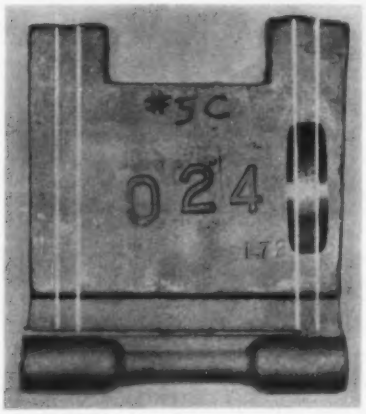
Cu	Ni	Mn	Sn	Fe	Pb	Si	Al	C	Ti	Cb	S
66.94	Bal.	0.81	<0.01	0.57	0.007	0.16	0.0006	0.003	0.044	0.03	0.009

FOUNDRY CONTROL

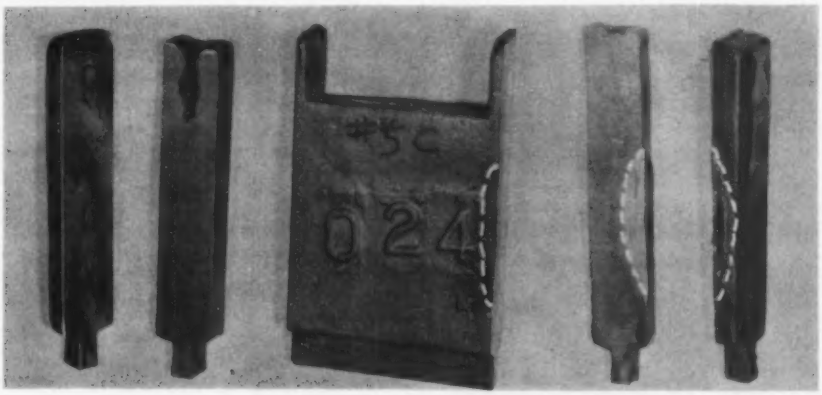
The foundry controls needed to produce material within the narrow composition range are greatly facilitated by a direct reading x-ray fluorescent spectrograph, which enables material to be held in the furnace until the desired composition is obtained.

A specimen approximately 1¾-in. round at base is cast in a tapered copper mold, knocked out after 2 min, ½-in. of the end cut off with a friction wheel, and smoothed on a disc sander. The controls are set for the desired elements and unknown samples are inserted, a button pushed and the data printed on

*A.S.T.M. — B225-53T (Class E Cu-Ni)
A.W.S. — A5.6-53T (Class E Cu-Ni)



Finish ⅜-in. thick.
⅜-in. deep
¾-in. wide.
2⅜-in. long.
4 in. diameter cutter.





Not welded



Welded

Degree of bend to failure in base metal, 180 degree. Weld — no cracks.

Fig. 13 — Restrained weld test on author's company specification 607; Webbert test A.S.T.M.-B206; Navy specification App. II, Part A. Jig for guided bend test in accordance to MIL standard 248, Fig. 6. Filled with 5 or 6 passes of $\frac{5}{32}$-in. rod with 140 amps (D.C. reverse polarity). U.S.N. QPL list for MIL-E-19323. Poured from heat L728-5C.

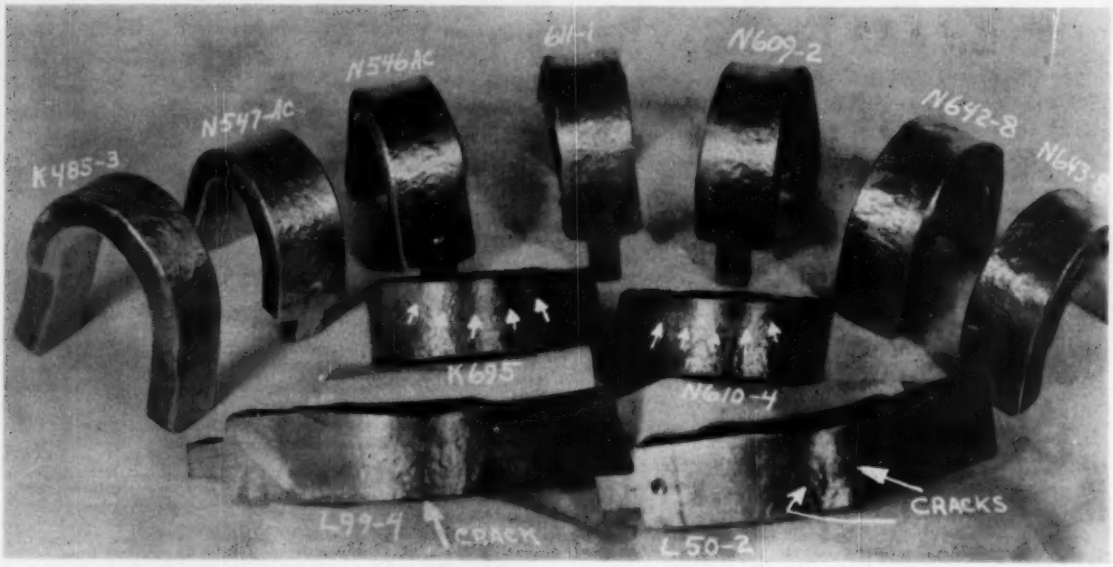


Fig. 14 — Bend test on welded samples.

a tape. The time from pouring to reporting analysis for five elements is approximately 6-7 min.

The establishment of practical specification values for any strength level is facilitated by the procedure shown in Fig. 15.

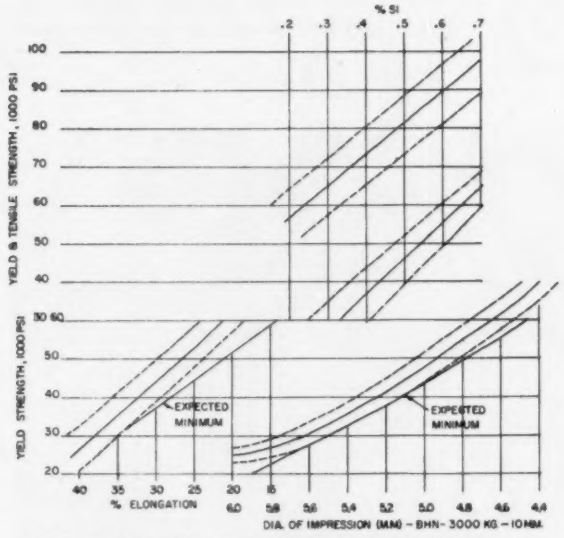


Fig. 15 — Specification values must be obtainable with the controls used on composition. Wherever physical properties are sensitive to composition, specification values can be realistically set by use of a property band, as shown above. The proper relationship of tensile strength to yield strength specification values can be obtained from the lower limit of the band. The per cent silicon necessary to produce this strength is shown on the graph, and establishes itself as the minimum value of the chemical specification. The range of silicon required to control this element establishes the maximum specification value for silicon. The expected yield strength with this maximum silicon governs the minimum elongation and Brinell hardness specification values. These are obtained from the relationship of yield strength to expected minimum values, as shown in the lower portion of the graph.

CONCLUSION

The desirable foundry characteristics of 70/30 cupro-nickel, particularly in thick sectioned castings, are accompanied by a sensitivity of physical properties and weldability as a function of chemical composition and cooling rate. Weldability is improved and physical properties increased for any given silicon content by additions of columbium.

Fast cooling through the red heat range reduces the physical properties, and the heavier sections of castings show higher strength valves due to the slower cooling, contrary to the usual assumptions. The maximum properties inherent in the composition can be developed by reheating to approximately 1200 F and cooling slowly to 500 F.

The physical properties of the columbium bearing 70/30 cupro-nickel are so superior that recognition of a new alloy is warranted. This is particularly important on account of the increasing utilization of 70/30 in castings.

ACKNOWLEDGMENT

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POROSITY-FREE MAGNESIUM ALLOY CASTINGS THERMAL REQUIREMENTS

by R. D. Green

ABSTRACT

A study of the effect of chills on sand cast magnesium revealed the conditions which must be met to obtain porosity-free metal. A thermal gradient of 5 F/in. must be established before the metal temperature falls more than approximately 50 F below the liquidus.

Thermal data were obtained from a wide size range of bar and plate castings. Typical thermal and mechanical property data from chilled and unchilled castings are presented. While this work was done with AZ63A, it is felt that the results are applicable to other Mg-Al-Zn casting alloys. The principles involved should hold for other Mg base alloys and also for other metals.

INTRODUCTION

An understanding of solidification and the factors which affect it is essential to the production of sound castings. Solidification mode can be modified in several ways. A popular method is by the use of chills to achieve directional solidification.

Although the use of chills is a long established foundry practice, it has been only comparatively recently that quantitative data on chill effects have been published. Empirical formulas have been derived to express the relationship between chills and the feeding range of risers for steel castings.[1] Other reports discuss the effect of chills on mechanical properties, grain size and heat treatability.[2,3] The critical size of chills has also received considerable attention.[1,4,5] The underlying theme of studies of chill effects has been to increase casting soundness by the elimination of porosity.

The sources of porosity are gas and solidification shrinkage. Baker[6] has demonstrated quite conclusively that porosity in properly melted and degassed magnesium alloy sand castings is due to solidification shrinkage. Shrinkage porosity results from feed blockage by several possible mechanisms. As crystals grow some of the feed channels may become too small for liquid metal to pass through them. Other possible mechanisms are blockage of feed channels by segregate particles or crystal growth. In any case, small pools of liquid metal are cut off from further feeding, and their shrinkage upon solidification results in porosity.

R. D. GREEN is Rsch. Engr., Met. Laboratory, The Dow Metal Products Co., Div. of The Dow Chemical Co., Midland, Mich.

In order to avoid porosity it is necessary to have progressive solidification (i.e., a narrow band freezing wave traveling toward a reservoir of molten metal). Since most alloys go through a mushy stage in solidification, directional solidification can be achieved only if adequate thermal gradients are present. The mode of directional solidification in alloys can be pictured by imagining a mushy band (liquid and solid) progressing through the metal. The liquid-mushy interface may be considered as the start of freeze and the solid-mushy interface as the end of freeze. The degree of directionality of solidification is determined by the relative width of the mushy band and its rate of travel. These are both functions of thermal gradients.

The mode of solidification of a given metal is influenced by several factors as explained by Bishop and Pellini.[7] These include the mold wall thermal properties, the liquidus to solidus range, thermal conductivity of the metal and the solidification temperature. Of the preceding, a long liquidus-solidus range, high thermal conductivity and a low solidification temperature are contributory to poor directional solidification and are characteristic of the Mg-Al-Zn casting alloys.

The only factor which can be modified to any great extent is the mold wall thermal properties. If sand is replaced by a metal chill, large quantities of heat can be absorbed and conducted rapidly from the interface. Thus, the interface is at a fairly low temperature, and steep thermal gradients are established by the solidifying metal. Under these conditions, solidification can progress directionally toward reservoirs of molten metal. The following data were obtained from a study of the thermal conditions required to achieve directional solidification in magnesium-base casting alloys.

APPARATUS AND PROCEDURE

A series of chilled and unchilled bar and plate castings was cast in green sand molds. The molds were made in a specially constructed flask, which permitted mold size variations while maintaining a fair degree of mold wall uniformity. The moisture content and mold hardness were measured and kept as constant as possible.

All melts were prepared from one batch of AZ63A

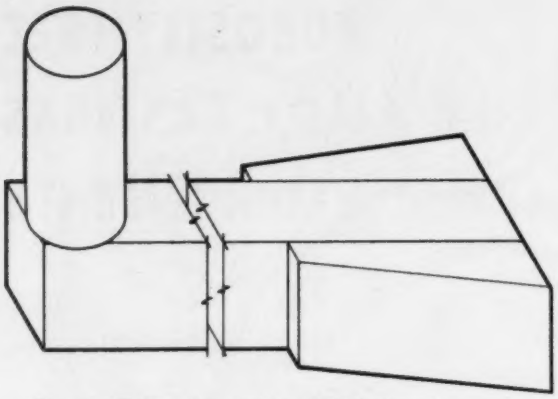


Fig. 1 — Bar casting showing chill placement.

ingots. AZ63A was used since it is the Mg-Al-Zn-Mn alloy with the greatest tendency for porosity.[9] The metal was chlorinated at 1350 F, superheated at 1650 F, allowed to cool at 1450 F and poured. A proprietary flux was used for protection.

The chill arrangements for bar and plate castings are shown in Figs. 1 and 2. The castings were poured from the riser end. The dimensions of the bar casting chills are given in Table 1, and the dimensions of the plate casting chills are shown in Fig. 3. The steel chills were scored with a ½-in. grid on the contact surface and sand blasted before each use. No chill wash was used.

Metal temperatures during solidification were recorded with a high speed, 16 point Brown recording potentiometer. Glass insulated iron-constantan thermocouples were placed at 2-in. intervals along the centerline and the mold-metal interface of the bar castings. Thermocouples were placed along the centerline, the quarter line and the mold-metal interface of the plate castings.

All of the castings were radiographed to locate porosity. Metallographic examination of some of the first castings resulted in porosity ratings the same as those obtained from the radiographs. Therefore, porosity in later work was determined solely by radiography.

Most of the castings were sectioned to provide specimens for mechanical property tests. Coupons were cut longitudinally from the bar castings (adjacent to the thermocouples) and transversely from the plate castings. The coupons were solution heat treated for 16 hr at 730 F, quenched on a cold plate, aged for 5 hr at 425 F, machined into test bars and tested.

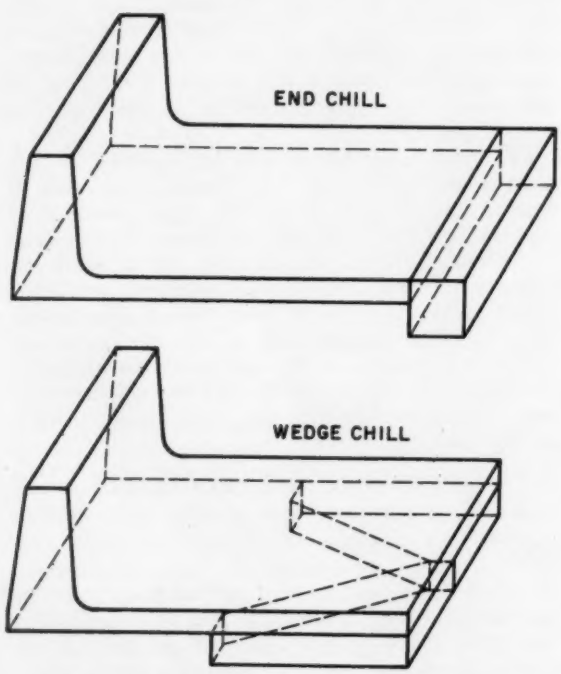


Fig. 2 — Chill placement for plate castings.

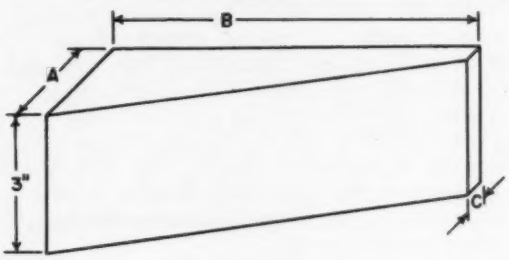
RESULTS AND DISCUSSION

Bar Castings

Twenty-four bar castings were prepared and studied, as listed in Table 2. The results obtained from unchilled 4x4 in. and 3x3 in. bars were so similar that only 3x3 in. bars were used to study chill effects. In all phases of this investigation, the similarity of results was so strong that only typical thermal data curves are shown.

Since we were interested in determining thermal gradients through the freezing range, the thermal data obtained were plotted as families of isochronous temperature distribution curves. A typical set of curves from an unchilled bar casting is shown in Fig. 4. The riser end is at the right. In order to determine the gradient necessary to achieve soundness, the bars were sectioned and radiographed. In general, the bars

TABLE 1 — CHILL DESIGNATIONS FOR BAR CASTINGS



CHILL DESIGNATION	DIMENSIONS (IN.) A	B	C
2 X 6	2	6	1/2
3 X 6	3	6	1/2
2 X 9	2	9	1/2
3 X 9	3	9	1/2
1 X 12	1	12	1/4
2 X 12	2	12	1/2
3 X 12	3	12	1/2
2X 15	2	15	1/2
3X 15	3	15	1/2

TABLE 2 — BAR CASTINGS STUDIED

Bar Size, in.	Chills Used
3x3x12	None
12	2x6
12	3x6
16	1x12
16	2x12
16	3x12
18	None
18	2x9
18	3x9
18	2x12
20	2x15
20	3x15
24	None
24	3x6
24	1x12
24	2x12
24	3x12
30	None
30	2x15
30	3x15
4x4x12	None
18	None
24	None
30	None

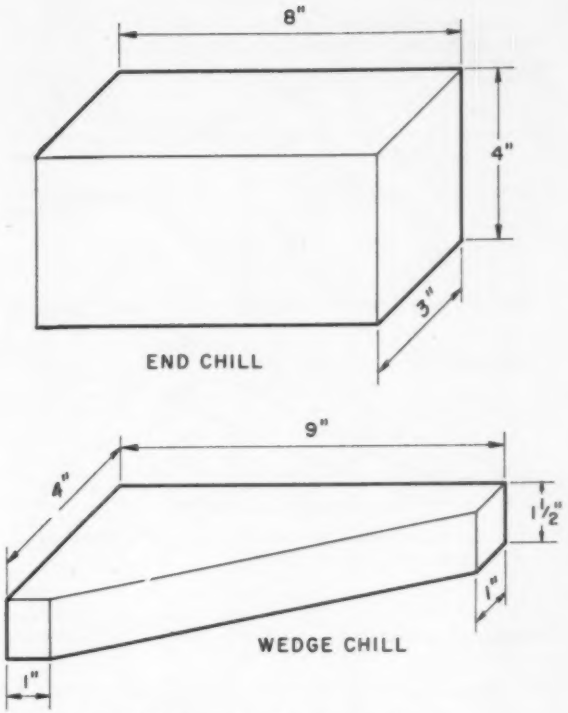


Fig. 3 — Chill dimensions for plate castings.

were sound for a length equal to the bar thickness from the dead end and slightly less than this from the riser end. Data revealed that sound metal was present in those areas where the thermal gradient had been at least 4-6 F/in. through the freezing range. A similar gradient has recently been reported for Al-7 Mg alloy.[10]

Figure 5 is a typical plot of the start and end of freeze curves for an unchilled bar casting. It is apparent that freezing is completed at the ends of the bars prior to the center. This can also be deduced from Fig. 4.

When the end of freeze curve is of the type shown in Fig. 5, there is little longitudinal movement of the freezing wave. All parts of the casting are cooling at approximately the same rate so that the entire casting is in a mushy stage. Any advance of the freezing front arises from end effects as well as movement from the four sides of the bar. The net result is that a long, isolated channel along the centerline is the last part to freeze. The mushy character of this last unfrozen portion is not conducive to good feeding, and porosity results.

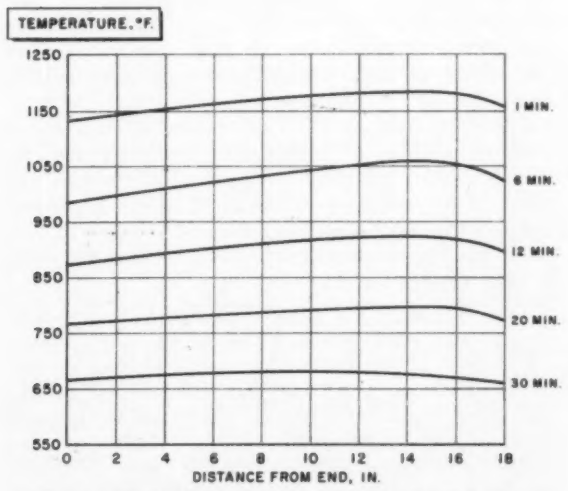


Fig. 4 — Center-line temperatures for 3 x 3 x 18 in. bar of AZ63A with no chills.

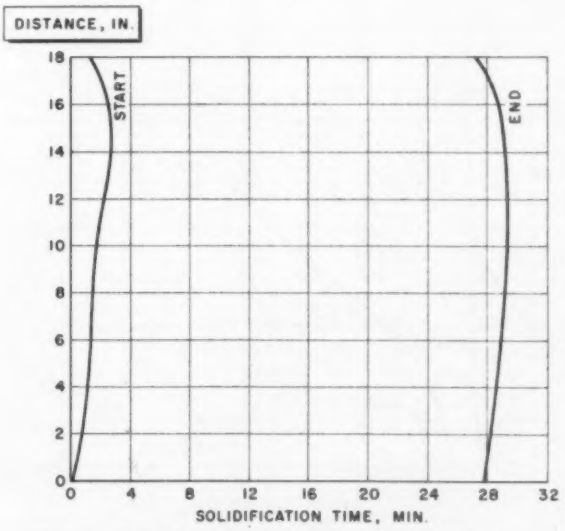


Fig. 5 — Start and end of freeze in 3 x 3 x 18 in. bar of AZ63A with no chills.

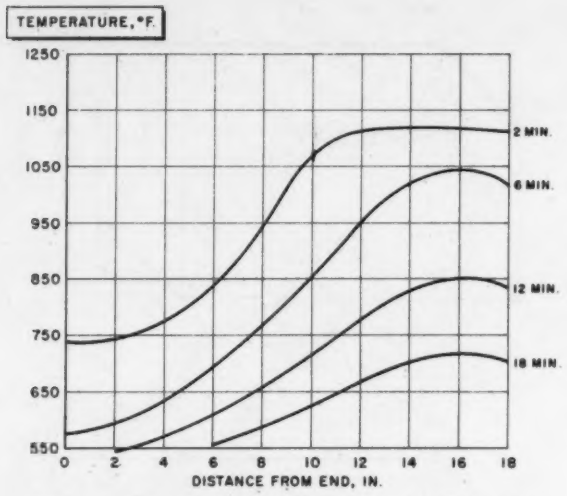


Fig. 6 — Center-line temperature in 3 x 3 x 18 in. bar of AZ63A with 3 x 9 chills.

Porosity Elimination

The most obvious remedy for the elimination of porosity in bar castings is to place the riser at the midpoint of the casting. However, for bars of appreciable length even this would not be satisfactory since the influence of end effects is quite small.

As mentioned earlier, chills can be employed to obtain steeper thermal gradients and thus, greater directionality of solidification. However, in order to be practical, the chills must be of such size and shape and so located as to promote longitudinal advance of the freezing front. If chills are used merely to speed up transverse travel of the freezing front, there is still the possibility of centerline porosity.

If wedge-shaped chills are placed on a bar casting, as shown in Fig. 1, the amount of heat extracted should vary with the chill thickness, which should cause transverse freezing at an angle to the mold wall. The movement of the intersection of the angular fronts is, in effect, a longtitudinal movement of the freezing front. In addition, the presence of steep thermal gradients through the front should result in narrow band freezing.

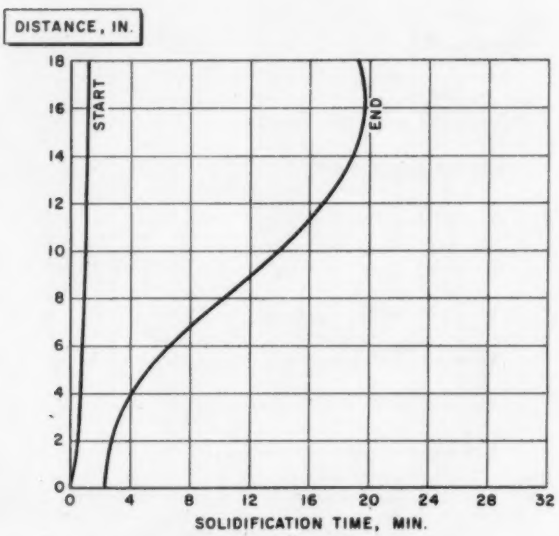


Fig. 7 — Start and end of freeze in 3 x 3 x 18 in. bar of AZ63A with 3 x 9 chills.

The manner in which wedge-shaped chills affect the temperature distribution in solidifying bar castings is shown by the typical curves in Fig. 6. The presence of strong longitudinal gradients is readily apparent. We would expect bars cast in this manner to be free of porosity, since the thermal gradient exceeds 5 F/in. Radiographs of the chilled bars, listed in Table 2, showed this to be the case in most instances.

Many of the bars were cast with thermocouples located at the chill-metal interface. When data obtained from these thermocouples are plotted, the slope is approximately the same as the slope of the temperature distribution at the casting centerline. However, the interface is at a lower temperature. The centerline and interface temperatures approach each other after the castings have cooled for approximately 2 min. From this we can deduce that there were steep transverse thermal gradients during the early part of the freezing process. The combination of longitudinal and transverse gradients results in directional solidification.

Wedge-Shaped Chills Effect

The marked influence of wedge-shaped chills on directional solidification is illustrated by the typical end of freeze curve of a wedge chilled bar casting shown in Fig. 7. While the start of freeze is about the same as that for unchilled bars the end of freeze curve is markedly different, and shows that the freezing front is advancing towards the riser.

It was noted earlier that a few portions of chilled bars which apparently had adequate thermal gradients still exhibited porosity. Some concurrent work[11] had revealed that Mg-Al-Zn alloys are almost completely frozen at only 50 F below the liquidus. When the data were re-examined, it was found that those portions of the bars which exhibited porosity had not attained a 5 F/in. gradient before cooling to 50 F below the liquidus. At this temperature the amount of solid already formed is sufficient to prevent feeding. In the case of Mg-Al-Zn alloys then, a thermal gradient of 5 F/in. must be attained before the metal temperature has fallen more than 50 F below the liquidus, despite the fact that the liquidus-solidus range is 280 F (1130 F – 850 F).

Test bars were cut from unchilled bars and from chilled and unchilled portions of the chilled bars. The results of the mechanical property tests are tabulated in Table 3. All bars cut from chilled castings met or exceeded the specified properties for bars cut from castings (QQ-M-56a). In fact, bars cut from chilled portions, with one exception, were acceptable at the property levels for separately cast test bars. All bars cut from unchilled castings failed to attain

acceptable property levels. These consistent results may be attributed to sounder metal, improved heat treatability and/or finer grain size in the chilled metal.

As expected, the chilled castings were more amenable to heat treatment than the unchilled castings. Figure 8 shows a few examples of this difference. The compound in the chilled bars is present in a less massive manner than in the unchilled bars. The net result of the combination of fine grain size and less massive compound is a decrease in the relative diffusion distance. This results in a more rapid and thorough response to heat treatment.

Plate Castings

Twenty-eight plate castings were made and studied, as listed in Table 4. The effect of the various chill configurations on temperature distribution in the solidifying castings is shown by the typical curves in Figs. 9, 10 and 11. In the case of the unchilled plate casting an adequate thermal gradient exists only about 3 in. from the end before enough solid is formed to prevent feeding. Transverse gradients are almost nonexistent, especially from the quarter line to the center line. This indicates that most of the casting is at about the same temperature and cooling at the same rate. Under such conditions it is impossible to achieve directional solidification, and a fairly porous casting is the inevitable result. Mechanical properties of such castings should be quite low.

When a large chill was placed across the end of the plate, the temperature distribution was as shown in Fig. 10. Steep thermal gradients were immediately established through the first 4 in. of the casting. Ten min were required before adequate thermal gradients were established the full length of the plate. However, by this time the amount of solid formed more than 10 or 11 in. from the dead end was too great for feeding to occur in the remainder of the casting, regardless of the thermal gradient. Mechanical properties of a casting such as this should be high at the chill end and decrease to approximately the level of unchilled metal about 10 in. from the chill end.

Longitudinal Thermal Gradients

When wedge chills were placed in the drag, the longitudinal thermal gradients were not as drastic as those produced by the end chill. However, as shown in Fig. 11, they extended for a greater distance, and were established at temperatures where they could be of significance in aiding feeding. In addition, appreciable transverse gradients were also established in a significant temperature range. The net effect then, was to produce a rather V-shaped freezing front which was readily accessible to feed metal. Mechanical properties of a casting such as this should be quite high at the chill end, and gradually decrease to a value a little higher than unchilled metal.

The effects of the various chill configurations can be seen quite clearly in Fig. 12. This shows the radiographic porosity in a series of unchilled, end chilled

TABLE 3 — MECHANICAL PROPERTIES OF AZ63A-T6 (CHILLED AND UNCHILLED)

Cast & Test Bar No.	Bar Length, in.	Chill Size, in.	Chill	E, %	TYS	TS	Properties Acceptable*
83456-1	12		No	1.5	14.3	21.7	No
83457-1	18		No	1.0	16.8	19.6	No
83457-2	18		No	1.0	12.8	13.2	No
83458-1	24		No	1.0	16.7	22.4	No
83458-2	24		No	1.0	10.1	12.9	No
83459-1	30		No	1.0	17.2	23.1	No
83459-2	30		No	1.0	16.4	20.8	No
83459-3	30		No	1.0	10.2	13.3	No
84335-1	12	2x6	Yes	8.0	18.4	40.0	Yes
84336-1	12	3x6	Yes	8.0	18.0	39.7	Yes
83480-1	18	2x9	Yes	6.0	18.8	36.1	Yes
84380-2	18	2x9	Part	4.0	16.4	32.7	Yes
84381-1	18	3x9	Yes	10.5	19.3	44.2	Yes
84381-2	18	3x9	Part	4.5	16.7	33.2	Yes
84464-1	24	2x12	Yes	3.5	17.6	32.0	Yes
84464-2	24	2x12	No	2.0	15.0	20.6	Yes
84465-1	24	3x12	Yes	7.0	19.2	40.0	Yes
84465-2	24	3x12	No	1.5	15.3	26.1	Yes
84552-1	30	2x15	Yes	10.0	19.3	43.6	Yes
84552-2	30	2x15	Yes	8.5	18.5	40.6	Yes
84552-3	30	2x15	No	3.5	15.6	26.4	Yes
84553-1	30	3x15	Yes	7.5	18.9	39.8	Yes
84553-2	30	3x15	Yes	4.0	18.5	41.9	Yes
84553-3	30	3x15	No	1.5	16.8	26.9	Yes
84693-1	18	2x12	Yes	5.5	19.1	37.8	Yes
84693-2	18	2x12	Yes	5.5	16.0	35.7	Yes
84757-1	24	3x6	Yes	7.5	17.2	39.4	Yes
84757-2	24	3x6	No	1.0	16.5	21.5	Yes
85216-1	16	2x12	Yes	5.0	18.4	36.4	Yes
85216-2	16	2x12	Yes	9.0	15.7	38.4	Yes
85217-1	16	3x12	Yes	3.1	18.0	30.7	Yes
85217-2	16	3x12	Yes	9.0	15.8	39.7	Yes
85218-1	20	2x15	Yes	4.0	18.0	34.2	Yes
85218-2	20	2x15	Yes	6.0	18.4	38.4	Yes
85219-1	20	3x15	Yes	4.5	18.6	37.1	Yes
85219-2	20	3x15	Yes	5.5	18.8	37.7	Yes

*On the basis of standards for bars cut from castings—QQ-M-56a.

NOTE: Where a chill size is given, and it says "No" in the chill column, this indicates that the test bar was cut from that portion of the bar between the end of the chill and the riser. Where it says "Part" it means that part of the test bar was in that portion of the bar between the end of the chill and the riser.

TABLE 4 — PLATE CASTINGS STUDIED

Plate Dimensions, in.				No.
Thickness	Width	Length	Chills Used	Cast
0.8	8	18	None	1
0.8	8	18	End	1
0.8	8	18	Wedge	1
1	8	18	None	2
1	8	18	End	2
1	8	18	Wedge	2
1.33	8	18	None	1
1.33	8	18	End	1
1.33	8	18	Wedge	1
2	8	12	None	1
2	8	18	None	3
2	8	18	End	3
2	8	18	Wedge	3
4	8	18	None	2
4	8	18	End	2
4	8	18	Wedge	2

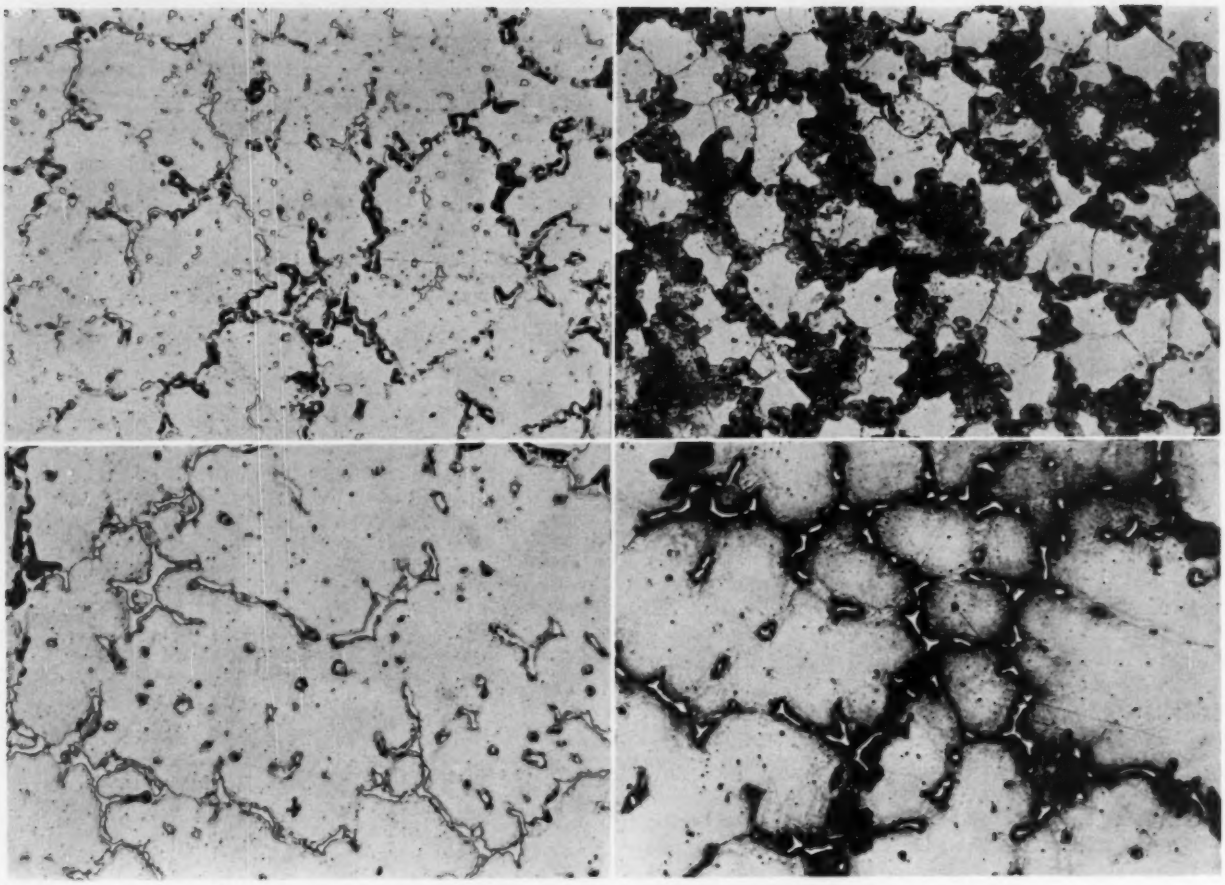


Fig. 8 — Chills effect on the heat treatability of AZ63A. *Top* — chilled metal; *bottom* — unchilled metal. *Left* — as-cast; *right* — solution heat treated and aged. Acetic glycol etch. 100 ×.

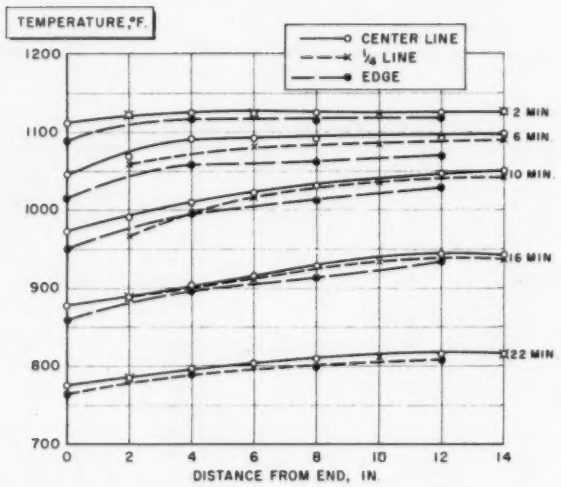


Fig. 9 — Temperature distribution in 2 x 8 x 18 in. plate of AZ63A with no chills.

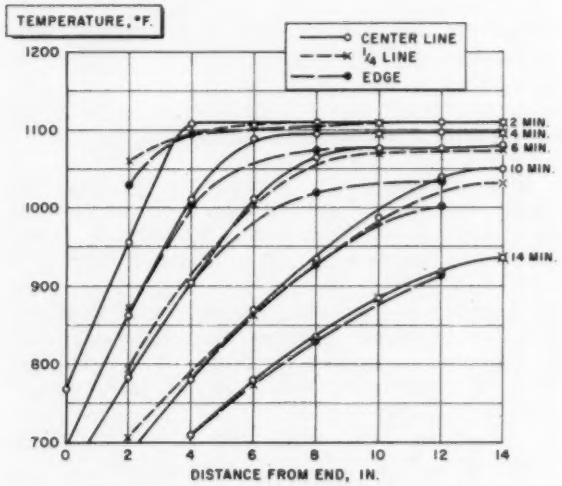


Fig. 10 — Temperature distribution in 2 x 8 x 18 in. plate of AZ63A with end chill.

and wedge chilled plates. The sketches are schematic, and serve to show only the location of porosity not the degree. The unchilled plates exhibit extensive porosity, except in those areas where edge effects established adequate thermal gradients for some directional solidification. When end chills were used, the plates were sound except under the riser in all but the 2-in. and 4-in. plates. With the exception of the 4-in. plate all the wedge chilled plates were sound, except that portion under the riser. The line or porosity shown extending down the center of the 4-in. wedge chilled plate is questionable. Although there were some indications of porosity on the radiograph they were extremely faint.

Temperature Distribution

It is quite revealing to compare the temperature distribution curves of Figs. 9-11 with the location of porosity in 2-in. plates shown in Fig. 12. It was earlier stated that the unchilled plate had adequate thermal gradients for 3 in. from the end, the end chilled plate for 10 in. from the end and the wedge chilled plate for the entire distance in which temperatures were recorded (14-in). The porosity distribution sketches show sound metal for 4 in., 11 in. and 15 in., respectively. The results show good agreement with the statement that thermal gradients of at least 5 F/in. must be established before the metal has cooled more than 50 F below the liquidus.

Mechanical properties were obtained to check the interpretations of the cooling curves and radiographs. The results of a typical series of tensile tests are shown in Fig. 13. The properties of these and

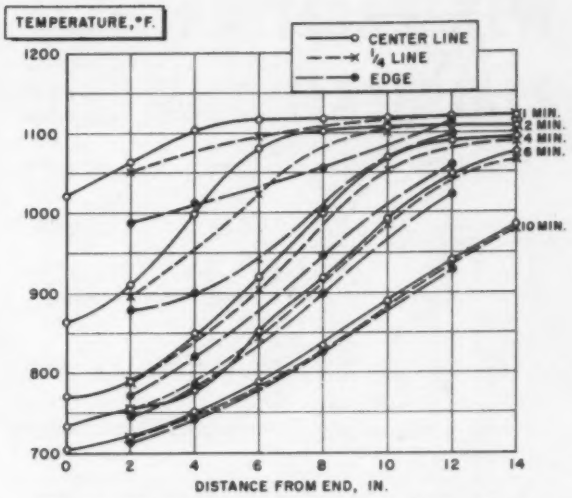


Fig. 11 — Temperature distribution in 2 x 8 x 18 in. plate of AZ63A with wedge chills.

other plate castings are tabulated in Table 5. As expected, the bars from the unchilled castings had the lowest and most uniform properties. The properties of end chilled plates were high close to the chill end and descended quite rapidly.

The properties of wedge chilled plates were also high close to the end, but fell off less rapidly than in the end chilled plates. Thus, the wedge chilled plates have the highest average properties. It is interesting to note that the shape of the property curves is similar to the curve one would obtain if the tem-

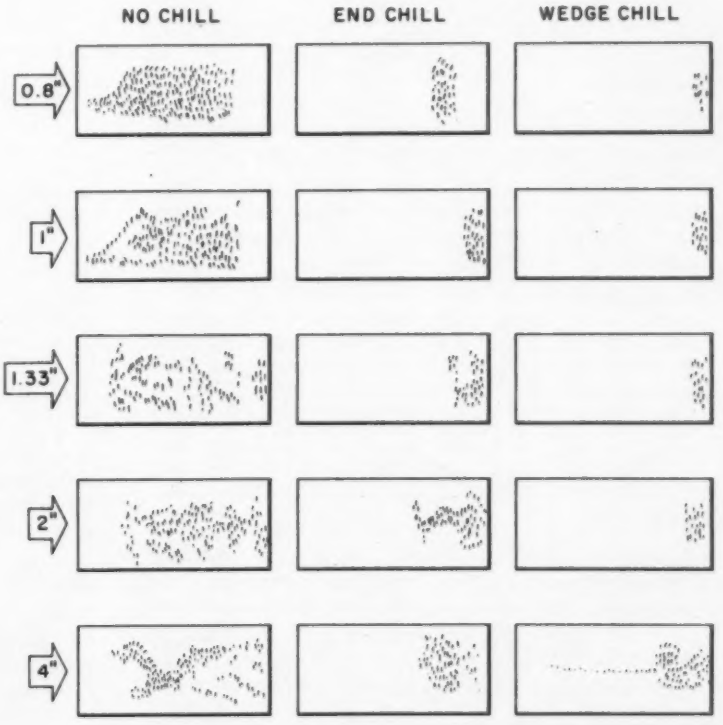


Fig. 12 — Radiographic porosity in 8 x 18 in. plate castings of AZ63A.

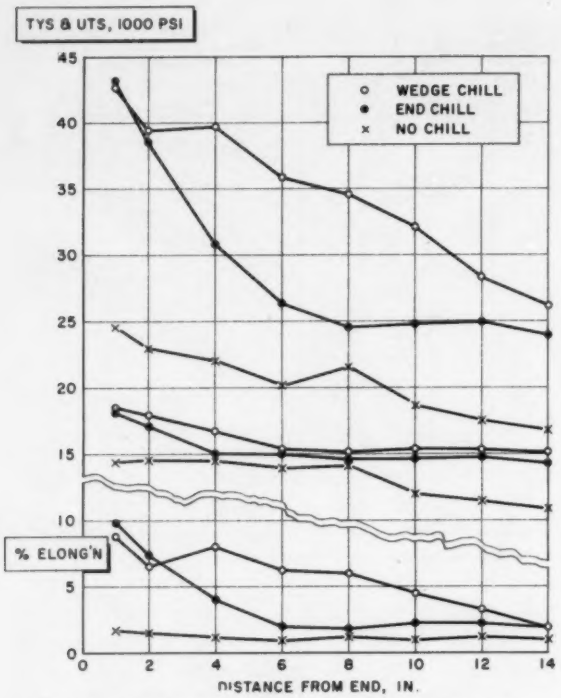


Fig. 13 — Mechanical properties of bars cut from 2 x 8 x 18 in. plates of AZ63A-T6.

TABLE 5 — MECHANICAL PROPERTIES OF BARS CUT FROM PLATE CASTINGS — AZ63A-T6

Distance From End (in.)	No Chills			End Chill			Wedge Chills		
		1,000 psi			1,000 psi			1,000 psi	
	E, %	TYS	UTS	E, %	TYS	UTS	E, %	TYS	UTS
1x8x18 plates									
1	3.7	18.6	34.4	8.0	19.1	42.9	3.5	19.7	34.5
2	3.7	18.4	35.0	6.5	17.0	38.2	6.5	18.6	39.2
4	3.7	18.6	34.5	4.5	16.7	33.8	10.0	16.8	40.9
6	3.7	18.2	34.2	3.8	16.7	31.8	7.7	16.6	39.4
8	3.7	17.9	34.2	3.8	16.5	31.2	6.5	16.4	37.1
10	4.5	17.5	34.0	4.0	16.2	31.4	5.8	16.3	36.0
12	4.7	16.9	33.9	4.5	15.8	33.0	4.8	16.1	33.8
14	7.5	15.6	36.9	4.5	15.0	31.6	4.5	15.6	32.6
2x8x18 plates									
1	1.7	14.5	24.6	9.7	18.1	43.3	8.8	18.6	42.9
2	1.5	14.6	23.0	7.3	16.2	38.6	6.5	18.0	39.4
4	1.2	14.5	22.2	4.0	15.0	30.6	8.0	16.4	39.7
6	1.0	14.0	20.1	2.0	14.9	27.5	6.2	15.2	35.5
8	1.2	14.1	21.6	1.8	14.6	24.6	6.0	15.2	34.6
10	1.0	12.1	18.6	2.2	14.6	24.8	4.5	15.3	32.3
12	1.2	11.4	17.1	2.2	14.6	25.0	3.2	15.2	28.4
14	1.0	11.1	16.8	2.0	14.2	23.9	2.0	15.2	26.2
4x8x18 plates									
1	1.0	14.6	22.7	6.8	16.2	40.2	4.5	17.3	34.4
2	1.0	13.6	18.7	4.0	14.9	31.2	3.7	16.5	33.2
4	1.0	13.8	18.6	2.5	13.7	28.0	3.5	15.5	30.5
6	1.0	12.3	16.7	1.2	13.7	22.4	3.2	15.1	28.2
8	1.0	13.1	18.0	1.2	14.1	21.7	2.8	14.5	26.3
10	1.0	13.5	17.4	1.0	12.9	18.2	2.8	14.6	25.4
12	1.0	14.0	19.7	1.0	11.2	15.9	2.0	10.1	15.0
14	0.7	14.2	18.3	1.0	11.2	14.7	1.5	8.7	12.6

perature distribution curves were rotated 180 degrees about a horizontal axis. This is one more means of illustrating the important role of thermal gradients in the production of sound castings.

SUMMARY

The thermal gradient required to produce sound Mg-Al-Zn alloy castings has been established as 5 F/in. This gradient must be established before the metal has cooled to more than 50 F below the liquidus. At this temperature the metal is approximately 90 per cent solid,[11] and feeding can no longer occur. A sufficient chill is then defined as one which results in directional solidification by establishing adequate thermal gradients in a significant temperature range (i.e., before the amount of solid formed is great enough to prevent feeding).

Although the data were obtained from AZ63A castings, the results should be applicable to other Mg-Al-Zn alloys as their solidification modes are similar.[11] Since recent work has shown the same gradient is required to produce sound castings of Al-7Mg alloy,[10] the results are probably typical of many aluminum-base casting alloys as well. Although the details may be different, the principles of solidification dictate that similar conditions must be met to attain directional solidification of any alloy that goes through a mushy stage when freezing.

While chills may be considered primarily as a means of achieving directional solidification, other benefits may accrue from their use. In the case of magnesium-base alloys these include a finer grain size and a structure which is readily amenable to heat treatment. All of these factors contribute to improved mechanical properties in castings.

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PLASTIC PATTERNS NEW TOOLS AND MATERIALS

by Frank Kobee

ABSTRACT

The use of new equipment and materials which supplement existing patternmaking techniques and thereby reduce patternmaking time and costs are described. A review of the progress in plastic patternmaking in the past five years indicates acceptance of plastics by many foundries and patternmakers. During this period of development epoxy plastic patterns have been made by laminating sheets of glass cloth to build up the desired pattern thickness.

The plastic used in this technique serves as the adhesive to cement or bond the sheets of cloth together, which results in a pattern structure of high strength. An alternate method is to cast or pour a liquid epoxy resin into a mold to form the pattern or core box. Casting or pouring plastic patterns is much faster than the laminating process where 10 to 15 layers of glass cloth are generally used to build up a pattern thickness. Because of the higher impact strength most foundries prefer the laminated type of pattern even though there are more man hours required.

A newly developed epoxy resin spray gun described heroin can help reduce laminating time and lower costs for this type pattern construction. Another newly developed metal spray gun will illustrate how the plastic facod plaster technique can be used for Keller patterns, core slugs, engraving models, permanent molds for plastic pattern fabrication, checking or gaging fixtures and short run foundry patterns.

INTRODUCTION

The acceptance of plastics by many foundries is a milestone in the never ending search for low cost pattern equipment. While plastic is not a cure-all, it has provided the third pattern medium. Wood patterns are almost always used to produce 700-1000 castings. Aluminum, steel or bronze patterns generally referred to as high production equipment, will produce 100,000 to 500,000 castings. No one will dispute that there is no substitute for good metal equipment. However, the cost to produce metal equipment is sometimes prohibitive especially in development or short run production. Some place between 700 to 1000 castings from a wood pattern, there is a place for another pattern material. Plastics appear to have the qualifications for intermediate range.

Thousands of plastic patterns have been made by casting liquid plastic into a suitable mold. It is a simple procedure and standard foundry practice of gating, risers, etc., are used. The casting plastics are usually formulated with aluminum powder, iron oxide, calcium carbonate and other fillers to provide wear characteristics, reduce shrinkage and to lower the heat rise (exothermic) when the resin is curing. These fillers serve their purpose. However, being a powder or granular substance, they do not render high impact or shock resistance. Consequently, when cast plastic patterns are subjected to the usual foundry abuse, they are chipped, cracked and often broken. The powdered fillers do not provide the tongue and groove or continuous filament reinforcement which is necessary to prevent fracture. Because of this low impact property many foundries are now specifying laminated glass cloth construction.

The merits of a laminated pattern have been known for a long time. However, because of economy the casting technique has been utilized to provide lower pattern cost. The material cost of the cast pattern versus the laminated pattern are approximately the same, but because of the tailoring and fitting of the glass cloth in corners and around ribs the man hours for a laminated pattern can be three to four times higher. Laminating is often referred to as hand layup. As the name implies, it is all hand work. Brushing on plastic with a paint brush or a squeegee is time consuming.

Moreover, a proper balance or ratio between the resin and glass cloth can not be achieved. When too much plastic is used a resin rich pattern will result. Many patterns ranged up to 75 per cent resin content. The ideal laminated pattern should be 50 per cent resin and 50 per cent glass cloth. It is virtually impossible to make a 50-50 laminate by brushing on plastic. The squeegee application approached the desired ratio more nearly than brushing. However, complex shaped patterns do not lend themselves to the squeegee application, and the resin content is in the range of 60 per cent.

EPOXY SPRAY GUN

To overcome this time consuming hand operation, an epoxy resin spray gun was developed to spray on and impregnate the glass cloth. Tests have disclosed that the laminating time can be reduced as much as 60 per cent for some pattern designs over the brush application. In addition, all test laminates were found to be in the 50-50 per cent resin to glass cloth range. The use of the spray gun makes laminating competi-

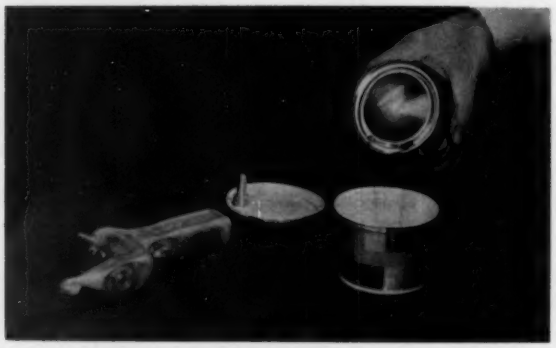
F. KOBEE is with Ohio Metal Fibers, Inc., Toledo, Ohio.

tive with casting, and it also provides a stronger laminate and a more desirable foundry pattern.

The epoxy spray gun was designed to spray premixed epoxy resin formulations. The gun will handle base and formulated resins with a viscosity range from 50-5,000 centipoises. The gun features a unique patent pending nozzle which permits the use of expendable cardboard resin container cups. The nonclogging easy to clean nozzle is available in several size openings to also permit spraying liquid parting agents.

The gun operates a 50-60 lb air pressure and weighs only 1½-lb. The throw-away resin cups will hold 8 oz to 2 lb of premixed resin. Epoxy laminates for tooling, patternmaking or production piece parts can be made with a lower resin content thereby reducing resin rich laminates. The uniform spray pattern provides quick impregnation and thorough wet-out of the glass cloth. One gun operator can keep four cloth applicators busy to reduce laminating time at least 60 per cent compared to brush application.

SPRAY GUN OPERATION



Premix epoxy resin and hardener, then pour into resin cup.



Place lid on cup and press firmly to lock lid and cup together.



Insert nozzle-lid-cup assembly into gun. The spring clip lock will hold assembled lid and cup in position during spraying operation.



With cup locked in place, spray epoxy resin as required to wet-out cloth. Adjust thumb screw to give desired spray pattern and resin flow. Use 50-60 lb air pressure.

When the resin cup is empty, remove the cup from gun, refill and continue to spray. When fast set hardener systems are sprayed, more frequent cleaning of the lid and nozzle is recommended. Clean gun by placing lid and nozzle in any solvent such as alcohol, acetone or methyl ethyl ketone. Use a pipe cleaner or electric shaver brush to clean straight through nozzle hole. Extra nozzles and lids are employed if continuous spraying is desired while previously used nozzle and lid is soaking in solvent. Discard throw-away cups after use, or when press fit seal is not sufficient to maintain air pressure.

In the development of plastics for patterns an inexpensive mold medium was deemed necessary. Hard plasters have been used over the period of years and found to be economical, and also provided the necessary dimensional accuracy. Molds made of gypsum cements have been used satisfactorily to reproduce one or two plastic patterns. However, when more than two duplicate patterns were required, the gypsum cement did not possess the reproducibility. The molds would chip or crack during the removal of the plastic pattern from the mold. This necessitated additional man hours for patching and repairs. Many foundries also insisted that the pattern shops keep a permanent negative or mold to produce additional patterns when necessary.

Protective coatings, lacquers and plaster hardeners

were evaluated to harden the gypsum cement mold surface. Unfortunately, there were no good brushable room temperature coatings that would improve the gypsum surface hardness.

To provide permanence many shops made laminated plastic molds. While this was lighter in weight and would produce a dozen duplicate patterns, it was found to cost from four to five times as much as the gypsum cement mold. In fact, the plastic mold cost was as much as the completed pattern. The problem was complex. The industry needed a mold medium with the hardness of the epoxy resin and the economy of gypsum cement (4c to 5c a lb). To overcome this problem, a new technique was developed which is now called the plastic faced plaster system. The method embodies the hardness of the epoxy and the economy of gypsum cement.

The process as illustrated in the photographs utilizes a newly developed fiber flow spray gun. The gun is designed to spray metal fibers in the range of 1/16 to 1/4-in. in length. Copper, steel and aluminum fibers are available, and found to be satisfactory. Aluminum fibers are recommended for economy and because of their stubby structure. On vertical walls the lightweight sprayed aluminum fibers will not run off or slump.

The hard durable plastic surface is inseparably bonded to the gypsum plaster splash by thousands of tiny metal fibers sprayed into a wet plastic surface coat or laminating resin using the specially designed gun. This technique provides a metal fiber plastic facing that is hard, tough, dense, durable and giving infinitely superior longer life to gypsum cement. In addition to molds for foundry patterns, the plastic faced plaster technique has been utilized for other patternmaking operations such as:

Keller patterns, vacuum forming molds (plastic), spotting blocks, core stick or slug, short run foundry patterns, prototype models, molds for polyester parts and duplicating and engraving models.

The following step by step illustrations show how to make a core stick or slug from a mold or core box. The completed plastic faced plaster will be a male impression from the female mold. The same procedure is used to make a female mold from existing or worn out pattern equipment.



After the mold or model is sealed with lacquer and given a coat of parting wax, a plastic gel coat or surface coat resin is brushed on. This could also be sprayed on with the epoxy resin spray gun. Laminating resins spray very well. Gel coats must be thinned to be sprayed.



Depending upon the application the fibers can be flocked into the surface or gel coat, or blown into a laminating resin which was applied after the surface coat hardened. In this way the fibers will not show through the surface.

This resin-fiber flocking operation is repeated three or four times to provide a metal interface for reinforcement of the gel coat. The multi-spray technique also provides more fibers for bonding the plaster backup. Use 20-25 psi air pressure. Higher pressures will create an over spray with a resulting waste of fibers. Fibers over sprayed on the work bench or floor can be swept up and used over.



The resin must be left to cure or harden at least 6 to 8 hr or over night. Then dust off any loose fibers before pouring the gypsum cement. Pour only enough cement to cover the fibers. Then brush the cement into the fibers to eliminate air between the gel coat and the cement.



Brushing the cement into the fibers insures a good mechanical bond. Failure to do this may create a weakness in the bond and the plastic face coat could separate from the back up material.



To reinforce the gypsum cement, fiber hemp is dipped into the cement and placed over the entire surface (left). Six or eight fiber bats dipped in the cement may be necessary to properly reinforce the core slug or mold.

Fill the remaining cavity with gypsum cement (right). It is most important that a low expansion cement be used. Molding or dental plaster is not recommended as the expansion is too great (approx. $\frac{1}{32}$-in./ft). The gypsum used should not expand more than 0.005 in. per ft.



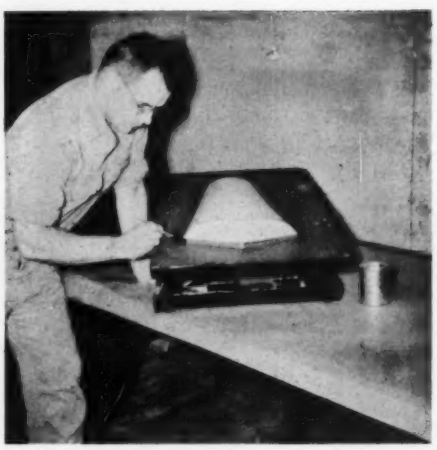
Do not remove the core slug or mold from the model until the cement has cooled to room temperature. Then use air pressure or push out pins to remove plastic faced gypsum cast or mold.

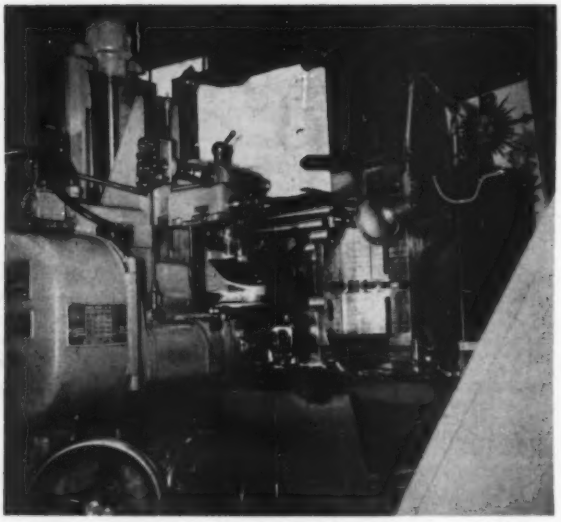


The plastic faced plaster concept has opened new opportunities for the patternmaker. In addition to permanent foundry pattern negatives or master molds shown, other pattern-making requirements can be carried out.



Typical Keller duplicator patterns made by the plastic faced plaster technique are shown. On the left is a forging die sinking pattern. The illustration on the right is a die sinking pattern for an automotive stamping.





The plastic faced plaster Keller pattern provides exceptional wear characteristics and is considered stylus proof. There were no more chipped corners as experienced with gypsum cement surface. Low cost is provided by the gypsum hemp reinforced back up.





Typical applications of short run foundry patterns which could be made by this new technique. The wood or metal frame provides protection from abuse in the foundry. With core plastic faced plaster foundry patterns could easily produce 3000 to 5000 castings.

TABLE 1 — MOLD COST COMPARISON (12x12x1 in.)

	Cast Plastic	Laminated	Plastic Faced Plaster
Labor Hr @ $3.00	1 hr — $ 3.00	4 hr — $12.00	1½ hr — $4.50
Material Cost	approx. 10 lb $1.20/lb $12.00	¼ in. Laminate — $ 6.00	plastic 35c fiber 50c gypsum 40c $1.25
TOTAL COST	$15.00	$18.00	$5.75

CONCLUSIONS

The use of plastics in conjunction with two new spray guns has been set forth to illustrate new time saving patternmaking methods. Test patterns made by spraying epoxy resin in a laminated glass cloth structure resulted in as much as 60 per cent in labor. In addition to savings in time a better laminate resulted. The spray application provides a more desirable plastic to glass cloth ratio.

With the development of the plastic faced plaster technique many duplicate foundry patterns can be made from a single plastic faced gypsum mold. In addition the completed plastic production pattern is reported to have a smoother surface than the one from a gypsum cement mold surface. Other applications such as Keller patterns, short run foundry patterns and checking fixtures would indicate that the technique is limited only to the patternmaker's imagination and ingenuity.

TABLE 2

Hard plaster alone	Dimensional stability, good wearing qualities when used in one or two shot applications, low cost — not as impact resistant as epoxies.
Plastic faced plasters	Labor and materials cost comparable to hard plasters, surface qualities comparable to cast or laminate epoxies, dimensional stability, requires less time to produce than cast epoxy, laminates or metal tooling.
Epoxy cast resins	Harder and denser surfaces, can be used as dies, more impact & compression strength, dimensional stability, good parting qualities in a foundry— more expensive than plaster, heavier than laminate.
Laminates	Surface conditions same as epoxy cast resins, lighter structure, more impact strength than plaster or epoxy cast resins because of impact resistance of fiberglas reinforcement — more labor expense.
Metal or wood patterns	Metal patterns will generally take more abuse than any other of these types — most costly to make generally, sometimes require machining and hand barbering, wood pattern surface is inferior to others.

Pattern end use requirements, job cost limits and delivery date are factors which often govern selection of proper method and materials.

GRAIN REFINEMENT OF COPPER

by G. C. Gould, G. W. Form and J. F. Wallace

ABSTRACT

Various methods of developing a commercially satisfactory method for refining the grain size of cast copper were investigated. Additions of metal powders and intermetallic compounds were made to serve as inoculants. The effectiveness of the peritectic reaction was checked by iron dissolved in molten copper, and metals were also added to restrict grain growth by constitutional supercooling or producing an adsorbed layer on the growing crystal.

Macrographic examination was employed to determine the effectiveness of the various additions on the grain size and shape. In cases where significant grain refinement was obtained, the mechanical properties and grain coarsening tendency were determined.

Two elements, lithium and bismuth, selected to produce constitutional supercooling, were effective in grain refining cast copper. When sufficient iron was dissolved to produce the peritectic, the effectiveness of this reaction was confirmed. A large number of presumed inoculants and additions to restrict grain growth proved inoperative.

INTRODUCTION

Control of the cast grain size is an important consideration to foundrymen because of the demonstrated influence of this grain size upon the physical and chemical properties of casting. Accordingly, this subject has been extensively investigated.[1-17] In spite of the considerable research effort expended, the mechanism of grain size control has not as yet been completely established. Failure to completely identify this mechanism can be attributed to the large number of interdependent variables influencing solidification and the resulting grain size.

In brief, grain refinement is obtained by increasing the number of sites from which crystals can grow in the melt. This can be achieved in one of two ways, or by a combination of both. First, substances in the form of fine, solid particles may be added to or produced in the melt to facilitate nucleation by providing stable nuclei on which the parent melt can readily solidify. Second, an alloying addition may be made for the purpose of decreasing the growth rate and allowing additional potential nuclei, already present in the melt as impurities or compounds, to become active.

The first method is called inoculation and the second, grain growth inhibition. It should be appreciated that the purpose of any addition is not merely to increase the number of nuclei, but to make a larger number of nuclei become effective. Only a portion of the total number of nuclei available in a melt will probably operate as nucleation centers during a solidification process, and it is only the effective nuclei that determine the as-cast grain size.

Inoculation and Grain Growth Inhibition Effect

The separate effects of inoculation and of grain growth inhibition can readily be demonstrated by considering the ingot solidification of an ideally pure metal. During freezing, a positive temperature gradient exists in the ingot from outside wall to center. Without any addition made to the melt, the as-cast structure will essentially consist of columnar grains extending to the center of the ingot. Adding an inoculating agent will increase the nucleation centers at the mold wall, resulting in a reduction of the width of the columnar grains without, however, affecting their length.

The columnar zone still extends to the center because of the positive temperature gradient existing throughout the entire solidification process, although it is comprised of more individual columnar grains. The addition of a grain growth inhibiting substance, on the other hand, may reduce the length of the columnar zone and promote equiaxed grain growth, provided this addition can produce sufficient supercooling of the melt, either thermally or constitutionally.[18-19] However, the equiaxed grains in the center may still be relatively coarse, because of lack of sufficient nuclei in the melt.

From this analysis it becomes apparent that complete grain refinement in a pure metal to yield a fine equiaxed grain requires both inoculation and grain growth restriction. However, for alloys or impure metals one of the two factors may already be operative so that in practice effective grain refinement can, under some circumstances, be achieved by inoculation or grain growth inhibition alone. The char-

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acteristics of additions to qualify as effective grain refining agents depend upon which of the above two functions must be fulfilled.

Successful inoculants should be solid, and stable at the melting temperature of the parent metal. In addition, good inoculants should be crystallographically compatible with the solidifying phase. These factors appear effective in reducing the positive surface-free energy which must be provided by the change in bulk free energy during freezing.

However, since different particles of similar lattice registry with the parent metal are not equally effective,[1] it must be concluded that chemical factors such as electron configuration and valency are also important. These factors apparently promote adhesion of parent atoms to the inoculant over cohesion in the solidifying melt.

Alloying Element Grain Growth Restricting Ability

The grain growth restricting ability of an alloying element has been attributed to two mechanisms: constitutional supercooling[18-19] because of a concentration buildup ahead of the solid-liquid interface, and saturation of surface forces of a growing crystal due to adsorption of appropriate solute atoms.[16] The factors governing growth inhibition on the basis of constitutional supercooling are a small distribution coefficient K,* a large freezing range, a steep temperature gradient across the mold and a slow diffusion rate of the solute (in either liquid or solid) relative to the freezing rate.[19] According to the adsorption theory, electronegativity and valency relative to the parent atom are important..

Some of the earliest work[20] in the field of refining the as-cast structure was directed toward utilizing the peritectic reaction. The method appears to combine inoculation with grain growth restriction. The significant factor governing the degree of grain refinement that can be achieved by using the peritectic reaction seems to be the size and distribution of the primary particles. The conditions that result in a fine, uniform distribution of these particles have not been established to date.

Employment of the peritectic reaction as a method of grain refinement has successfully been applied to aluminum. Unfortunately, the number of alloying additions which form a peritectic with the base metal at a sufficiently low solute concentration is limited for most commercial metals.

MATERIALS AND PROCEDURE

Melting and Method of Addition

The present investigation was undertaken with the primary intent of developing procedures for the grain refinement of copper by means of addition agents. Since many cast copper-base alloys are now coarse grained when employed commercially, such a development should result in improved properties of these alloys, including the Cu-Al, Cu-Zn and Cu-Sn systems. In addition, this investigation was also intended to clarify some of the apparent discrepancies of the mechanism of grain refinement.

Electrolytic copper of the general composition shown below was used as the base metal throughout the entire investigation:

Analysis of the Base Copper						
Element	Ge	Mo	Zn	Ag	Residuals (each)	Cu
Weight %	0.100	0.011	0.0025	0.002	0.001	99.883

The electrolytic copper was melted in a gas-fired furnace employing a clay-graphite, removable crucible. Deoxidation of all metals was performed by additions of approximately 0.050 per cent by weight of phosphorus added as 15 per cent phos-copper. The alloying additions or inoculants were inserted into the crucible immediately prior to pouring, usually by means of a refractory plunger. The superheating (in the crucible) and pouring temperatures were generally held constant at 2200 and 2100 F, respectively, except where indicated otherwise in the results.

The molten copper was poured in most cases into a thin walled steel mold, 4.5 in. in diameter, and 8 in. high with a 2 degree taper. The mold was preheated to 400 F and sprayed with a ceramic mold wash before pouring. The base of the steel mold consisted of a 2 in. thick steel plate that served as a bottom chill. This type of mold and the pouring temperature employed consistently produced columnar solidification of the unmodified copper. In this manner, the effectiveness of a given addition in reducing the grain size of the copper could be readily determined.

Selection of Additions

Powders of metals were added as inoculants where the inoculant was intended to be the element itself or an intermetallic compound generated by the reaction of the metal powder. At the outset, only those stable inoculants with a cubic crystal structure (FCC, BCC, CsCl, NaCl) were employed. The number of stable elements and compounds is rather limited so that other types of inoculants were also employed. These latter materials were chosen primarily because their melting points were higher than that of copper.

Table 1 shows the types and amounts of the inoculants added in this investigation, and some of their pertinent properties. The cobalt, iron and tungsten were added as a finely divided powder, under 200 mesh. The remaining additions were intended to produce intermetallic compounds of the type shown in each case.

The method employed in the attempt to produce these compounds consisted of a double addition. First, the second element of each compound listed in Table 1 was added to molten copper at 2200 F and dissolved. Then, the first element of each compound was introduced into the melt. The procedure consisted of first adding the more stable, usually higher melting temperature metal to copper followed by the second addition of the lower stability metal to form the compound.

In a number of instances, the particles were found

*Ratio of solute in the solid to solute in the liquid.

to segregate during solidification. This segregation tendency was particularly pronounced in those cases where the difference in density of the inoculant relative to copper is large. The intermetallic compounds listed in Table 1 were formed by means of a reaction mixture to assure clean, reactive surfaces on which the parent metal could solidify, as well as a fine and uniform distribution of the inoculant throughout the melt.

Adsorption Theory

Additions made for the purpose of grain growth restriction included those selected on the basis of the adsorption theory and others intended to produce appreciable constitutional supercooling. Only two elements, namely selenium and tellurium, were added in an attempt to form an adsorbed, interfering layer. According to the adsorption theory, these two elements should be most effective in reducing the length of the columnar zone in a copper casting. A considerable number of elements and some combinations were employed to produce constitutional supercooling. These additions were made to molten copper in various amounts ranging from 0.02 to 1.32 weight per cent. The elements added in this group to restrict grain growth, the amount, intended function and pertinent characteristics are listed in Table 2.

Some of these additions (notably lithium, magnesium and calcium) exhibited a marked tendency to oxidize, and were, therefore, plunged immediately before pouring. The chemical analyses made to determine retention of some of these oxidizable alloys indicated that this procedure retained approximately 90 per cent of the addition agent in the melt. Since the latter are all soluble in molten copper, no liquid segregation problems were encountered.

Iron and cobalt additions constitute a special group since these metals form a peritectic system with copper. As previously discussed, the peritectic reaction may provide both effective nuclei and grain growth restriction. When added in sufficient amounts to molten copper so that the peritectic is encountered during solidification, these additions are referred to as peritectic additions. On the other hand, if the addition is too small for the peritectic reaction, these two elements are either classified as alloys producing constitutional supercooling or inoculants, depending on whether the conditions under which they are added are conducive to their total dissolution in copper, or whether the particles remain at least partially solid and therefore act as inoculants.

Tests Performed

The effect of the various additions on the as-cast grain structure was determined on longitudinal center cuts of the ingots after etching with a 50 per cent HNO_3 solution. A comparison was made with the standard, unmodified copper casting, shown in Fig. 1, to serve as a basis for this evaluation.

Mechanical and physical properties were limited to those castings on which pronounced grain refinement was apparent. The tensile tests were obtained on button-head specimens with a diameter of 0.3 in. and a 1.4 in. gage length. Electrical conductivity measurements were preformed by means of a Kelvin bridge on wire samples swaged and drawn to a final diameter of 0.102 in. and then annealed. The sen-

TABLE 1 — INOCULANTS ADDED TO COPPER

Inoculant	Concentration Wgt., %	Crystal Structure	Lattice Parameter, kX a	b	c	Density gm/cm³	Melting Point, F
Cu	—	FCC	3.607	—	—	8.96	1981
Co	0.85	FCC	3.552Å	—	—	8.90	2723
Co	0.77	FCC	3.552Å	—	—	8.90	2723
Co	0.02	FCC	3.552Å	—	—	8.90	2723
Fe	2.42	FCC	3.639	—	—	7.87	2802
Fe	1.32	FCC	3.639	—	—	7.87	2802
Fe	0.02	FCC	3.639	—	—	7.87	2802
Fe	0.001	FCC	3.639	—	—	7.87	2802
W	0.01	BCC	3.158	—	—	19.30	6170
AlCo	0.50	BCC	2.856	—	—	—	2993
AlFe	0.50	BCC	2.903	—	—	—	2143
AlNi	0.50	BCC	2.288	—	—	6.66	2980
Ca_2Pb	0.50	?	?	—	—	?	2030
CaSn	0.50	Orthor.	4.821	11.52	4.394Å	4.28	2048
CaSi	0.50	Orthor.	4.59	10.79	3.91 Å	2.34	2273
$PbCe_2$	0.50	?	?	—	—	?	2516
$SnCe_2$	0.50	?	?	—	—	?	2552
$PbLa_2$	0.50	?	?	—	—	?	2399
$SnLa_2$	0.50	?	?	—	—	?	2588
Mg_3Sb_2	0.50	Mn_2O_3	4.573	7.229	—	4.09	2244
Mg_2Si	0.50	CaF_2	6.338	—	—	—	2014
SbNi	0.50	NiAs	3.916	5.132	—	8.78	2107
Sn_2Ni_3	0.50	Ni_2In	4.137	5.203	—	—	2308
TiC	0.50	NaCl	4.329	—	—	—	5880
TiCo	0.50	CeCl	2.988	—	—	—	2182
$TiFe_2$	0.50	$MgAn_2$	4.750	—	—	6.50	2786
$TiNi_3$	0.50	Ni_3Ti	2.550Å	—	—	—	2512

TABLE 2 — ALLOY ADDITIONS EMPLOYED TO RESTRICT CRYSTAL GROWTH

Addition	Function	Conc. Wgt., %	Dist. Coef., K		Freezing Range, F
Bi	Const. Supercool	0.50	0.002	•	810
Bi	Const. Supercool	1.20	0.00083	•	805
Bi	Const. Supercool	2.60	0.0004	•	800
Li	Const. Supercool	0.02	0.05	•	914
Li	Const. Supercool	0.05	0.02	•	900
Li	Const. Supercool	0.05	0.02	•	900
Li	Const. Supercool	0.07	0.01	•	900
Li+Bi	Const. Supercool	0.05+0.50	?	•	900 (?)
Li+Bi+Sb	Const. Supercool	0.05+0.50+0.50	?	•	900 (?)
Pb	Const. Supercool	0.10	0.01	•	767
Pb	Const. Supercool	0.50	0.002	•	749
Pb	Const. Supercool	1.00	0.001	•	714
Ca	Const. Supercool	1.20	0.83	••	100
Mg	Const. Supercool	0.50	0.20	••	20
Sn	Const. Supercool	1.00	0.10	••	60
Fe	Peritectic	2.42	——		10
Fe	Const. Supercool	1.32	1.89		5
Fe	Const. Supercool	0.02	1.89		5
Co	Const. Supercool	0.96	1.36		5
Co	Const. Supercool	0.75	1.94		5
Cr	Hypereutectic	1.70	——		20
Se	Adsorption	1.50	——		36
Te	Adsorption	0.50	——		50

• Equilibrium phase diagrams available indicate practically no solid solubility of Bi, Li and Pb in copper.

•• Equilibrium phase diagrams available indicate limited, but some solid solubility of Ca, Mg and Sn in copper.



Fig. 1 — Sectioned, ground and etched copper ingots (left to right) pure copper, copper plus 0.001 per cent Fe and copper plus 0.03 per cent Fe. ½ ×.

sitivity of these measurements was ±0.1 per cent conductivity. Recrystallization and grain coarsening tendencies were ascertained on the lithium-containing samples after a reducton of 61 per cent by rolling.

RESULTS

The effects of the additions to copper on the as-cast macrostructure are given in Table 3. A tabulation of type and concentration of these additions, their function and a qualitative description of the macrostructure is contained in this table. The appearance of the as-cast structure is described as one of the following three categories:

1) *Columnar.* A structure not different from that of the pure copper control casting, shown in Fig. 1.
2) *Equiaxed.* No directional growth of crystal; average grain diameter is 0.30mm or larger, as shown by Fig. 3.
3) *Fine Equiaxed.* No directional growth of crystals; average grain diameter less than 0.30mm, as shown by Fig. 4.

Addition of the metal powders iron, cobalt and tungsten for the purpose of inoculation required a modification of the standard casting practice employed. In order to maintain these powders as solids in the melt and avoid their dissolution, it was necessary to reduce the maximum superheating temperature prior to deoxidation and inoculation to 2100 F. This practice resulted in a pouring temperature of not more than 50 F above the melting point of the base copper.

In order to determine whether this deviation from the standard casting practice would influence the

TABLE 3 — ADDITIONS TO COPPER AND APPEARANCE OF RESULTING MACROSTRUCTURE

Addition	Concentration Wgt.. %	Function	Macrostructure	Avg. Grain Diameter	
				Dia. mm	Length mm
Co (pwd)	0.85	Inoculant	Fine Equiaxed	0.25	—
Co (pwd)	0.77	Inoculant	Fine Equiaxed	0.25	—
Fe (pwd)	0.02	Inoculant	Fine Equiaxed	0.25	—
W (pwd)	0.01	Inoculant	Fine Equiaxed	0.25	—
Intermetallic Compounds*		Inoculant	Columnar	3.0	30
Bi	0.50	Constitutional Supercool	Equiaxed	0.360	—
Bi	1.20	Constitutional Supercool	Equiaxed	0.360	—
Bi	2.60	Constitutional Supercool	Equiaxed	0.30	—
Li	0.02	Constitutional Supercool	Fine Equiaxed	0.20	—
Li	0.05	Constitutional Supercool	Fine Equiaxed	0.250	—
Li	0.05	Constitutional Supercool	Fine Equiaxed	0.250	—
Li	0.07	Constitutional Supercool	Fine Equiaxed	0.200	—
Li+Bi	0.05+0.50	Constitutional Supercool	Fine Equiaxed	0.180	—
Li+Bi+Sb	0.05+0.50+0.50	Constitutional Supercool	Fine Equiaxed	0.180	—
Pb	0.10	Constitutional Supercool	Columnar	3.0	30
Pb	0.50	Constitutional Supercool	Columnar	3.0	30
Pb	1.00	Constitutional Supercool	Columnar	3.0	30
Ca	1.20	Constitutional Supercool	Columnar	3.0	30
Mg	0.50	Constitutional Supercool	Columnar	3.0	30
Sn	1.00	Constitutional Supercool	Columnar	3.0	30
Fe	2.42	Peritectic	Fine Equiaxed	0.13	—
Fe	1.32	Constitutional Supercool	Columnar	3.0	30
Fe	0.02	Constitutional Supercool	Columnar	3.0	30
Co	0.96	Constitutional Supercool	Columnar	3.0	30
Co	0.75	Constitutional Supercool	Columnar	3.0	30
Cr	1.70	Hypereutectic	Columnar	3.0	30
Se	0.50	Adsorption	Columnar	2.0	20
Te	0.50	Adsorption	Columnar	2.0	20
Se+Li	0.50+0.02	Adsorption+Const. Supercool	Columnar	3.0	30

*0.50 wgt. % of the following intermetallic compounds resulted in columnar macrostructure: AlCo, AlFe, AlNi, Co_2Pb, Co_2Sn, CaSi, $PbCe_2$, $PbLa_2$, $SnLa_2$, Mg_3Sb_2, Mg_2Si, SbNi, Sn_2Ni, TiC, TiCo, $TiFe_2$, and $TiNi_3$

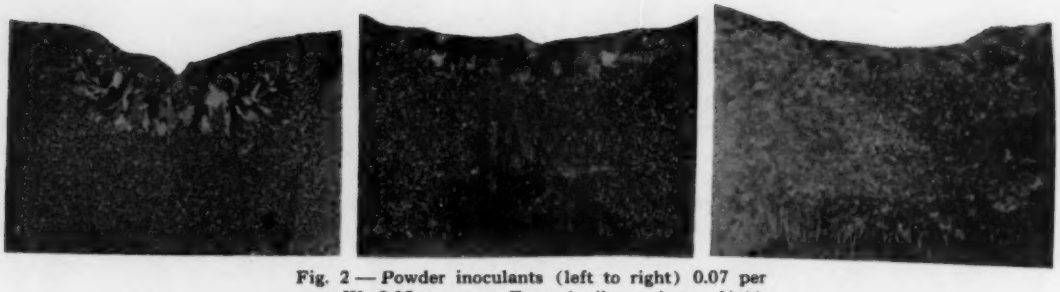


Fig. 2 — Powder inoculants (left to right) 0.07 per cent W, 0.05 per cent Fe and vibrant ingot. ½ ×.

grain size of the uninoculated base copper, several melts of untreated copper were cast at various temperature below 2100 F down to almost the melting temperature (1981 F). At all pouring temperatures, the uninoculated copper exhibited a coarse columnar structure. These results guaranteed that any grain refinement observed with metal powder addition was the result of their inoculating influence.

Considerable grain refinement was obtained with all three powders. The effect of iron and tungsten is shown in Fig. 2. At superheats over 120 F, however, these metal powders failed to produce any effective refinement, apparently because they dissolved in liquid copper.

Intermetallic Compounds as Inoculants

The use of other additions to produce intermetallic compounds as effective inoculants was generally unsuccessful since no grain refinement was achieved with these materials. As previously mentioned, a special double addition procedure was employed to form the intermetallic compound through an exothermic reaction. The reasons for no grain refinement in these cases may be attributed to either lack of formation of effective intermetallic compounds or too steep a thermal gradient in the solidifying casting preventing nucleation of separate grains ahead of the solid-liquid interface.

The failure to produce effective inoculation with metal powders under conditions of appreciable superheat and with reaction mixtures led to the investigation of grain growth restriction to achieve commercially feasible grain refinement. The additions listed in Table 2 were made to accomplish this purpose. Small amounts of two of the elements added to produce appreciable constitutional supercooling (bismuth and lithium) were particularly effective in obtaining a fine, equiaxed grain structure as demonstrated in Fig. 3.

Those metals were selected because of the large liquidus-solidus spread in the Cu-Bi and Cu-Li equilibrium phase diagrams, resulting in a small distribution coefficient K as shown in Table 2. Since the K-value in the Cu-Pb system is also low, small amounts of lead were added to copper. However, this latter addition did not produce any observable refinement and all the lead-treated castings had a completely columnar macrostructure.

Calcium and magnesium additions were also unsuccessful in producing any marked refinement, although some solute concentration buildup ahead of the solid-liquid interface was anticipated from phase diagram considerations.

Combinations of bismuth and lithium added as constitutional supercoolers exhibited a cumulative effect, as shown in Fig. 4. Combinations of lithium and selenium, i.e., an adsorption and a constitutional supercooling addition, gave little or no grain refinement. This is tentatively attributed to a chemical reaction between the two additions which removed the lithium from solution, but this has not yet been verified experimentally.

Peritectic Reaction Significance

The significance of the peritectic reaction was investigated by dissolving various amounts of iron and cobalt in liquid copper. When these elements were added at normal (2200 F) superheats in amounts appreciably smaller than necessary for the peritectic reaction to occur during freezing, the macrostructure consisted of coarse, columnar grains, as shown in Fig. 1. Pronounced grain refinement was obtained with 2.42 weight per cent iron (Fig. 5).

Although this amount of iron is somewhat less



Fig. 3 — Bismuth additions to copper (left to right) 0.5, 1.2 and 2.6 Wt per cent Bi. ½ ×.



Fig. 4 — Ingots grain refined by alloy additions of (left to right) Li, Li plus Bi and Li plus Bi and Sb. ½ ×.

than the value reported for the occurrence of the peritectic reaction under equilibrium conditions (approximately 2.8 weight per cent iron), this reaction may have taken place under the rapid cooling conditions prevailing during the experiment.[21] In order to determine whether the presence of the solid properitectic γ particles or the peritectic reaction itself was the important factor responsible for the pronounced grain refinement, shown in Fig. 5, a hypereutectic Cu-Cr alloy, containing 1.70 weight per cent chromium was poured.

A proeutectic phase of nearly pure chromium is separated first from the melt, followed subsequently by the eutectic reaction. Examination of the etched section of the ingot revealed a coarse columnar structure. This result suggests that the primary chromium particles had no significant effect on subsequent solidification, and therefore seems to underline the role played by the peritectic reaction in the Cu-Fe system.

No measurable grain refinement was obtained with either selenium or tellurium. These elements were added because of their reported ability to restrict grain growth according to the adsorption theory. The influence of these elements in improving machinability was observed, however.

The mechanical properties of copper ingot refined with additions of bismuth and lithium and combinations thereof were determined together with a control of pure cast copper. The properties of the control sample were in accord with values for as-cast electrolytic copper found in the literature.[22] In all cases the tensile strength and elongation were increased by refinement; however, the electrical conductivity was markedly lowered as shown below:

Alloy	U.T.S., lb/in.²	Elong., %	Elec. Cond., %
Cu	28,000	23.8	89.9
Cu + Li(0.05), Fig. 4	32,000	26.2	37.8
Cu + Bi(0.5) + Li(0.05), Fig. 4	31,300	30.0	—
Cu + Bi(0.5) + Li(0.05) + Sb(0.5), Fig. 4	33,600	36.5	35.6

In view of the influence exerted by lithium on the formation of crystals from the copper melt, an examination was undertaken to determine whether this influence was also exerted in the solid state during recrystallization. The results, shown in Fig. 6, suggest that this is the case, since the hardness

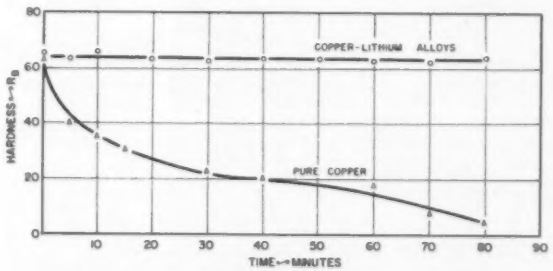


Fig. 6 — Recrystallization behavior of pure copper and copper-lithium alloys deformed 61 per cent by rolling and annealed at 660 F for various times.



Fig. 5 — Copper plus 2.42 per cent Fe grain refined by peritectic reaction (left) and pure copper control (right). ½ ×.

measurements indicate that the onset of recrystallization occurs much more readily in pure copper than in Cu-Li alloys. The tendency for grain coarsening during recrystallization is also lower for the alloys than for pure copper, as shown in Fig. 7.

GENERAL DISCUSSION

Before interpreting the results described above, the basic principles underlying solidification will briefly be reviewed. Inoculation can best be understood by comparing homogeneous (absence of preferred sites of nucleation) to heterogeneous nucleation. For a stable, solid nucleus to form in the melt, energy must be provided to create the interface between the crystal and the liquid.

This energy is supplied by the difference in chemical free energy between the solid and liquid state. Since at the equilibrium melting temperature, this chemical free energy difference is zero, undercooling is required to form a stable solid nucleus. For the case of homeogeneous nucleation in pure metals, the required degree of supercooling may be as high as 300 F.[23]

In the presence of foreign particles, heterogeneous nucleation will occur by the formation of stable nuclei of the parent metal at already existing surfaces in the melt (foreign particle surfaces). The use of these foreign surfaces reduces the interfacial energy term compared to that involved in homogeneous nucleation, so that stable nuclei can form at a lower degree of supercooling.

The effectiveness of a foreign particle in facilitating nucleation becomes more pronounced the smaller the interfacial energy between solid metal and foreign particle. As was pointed out in the introduction, good crystallographic matching between parent metal and foreign particle is desirable, although not always sufficient to minimize the surface energy between the metal and the foreign particle to form a stable nucleus.

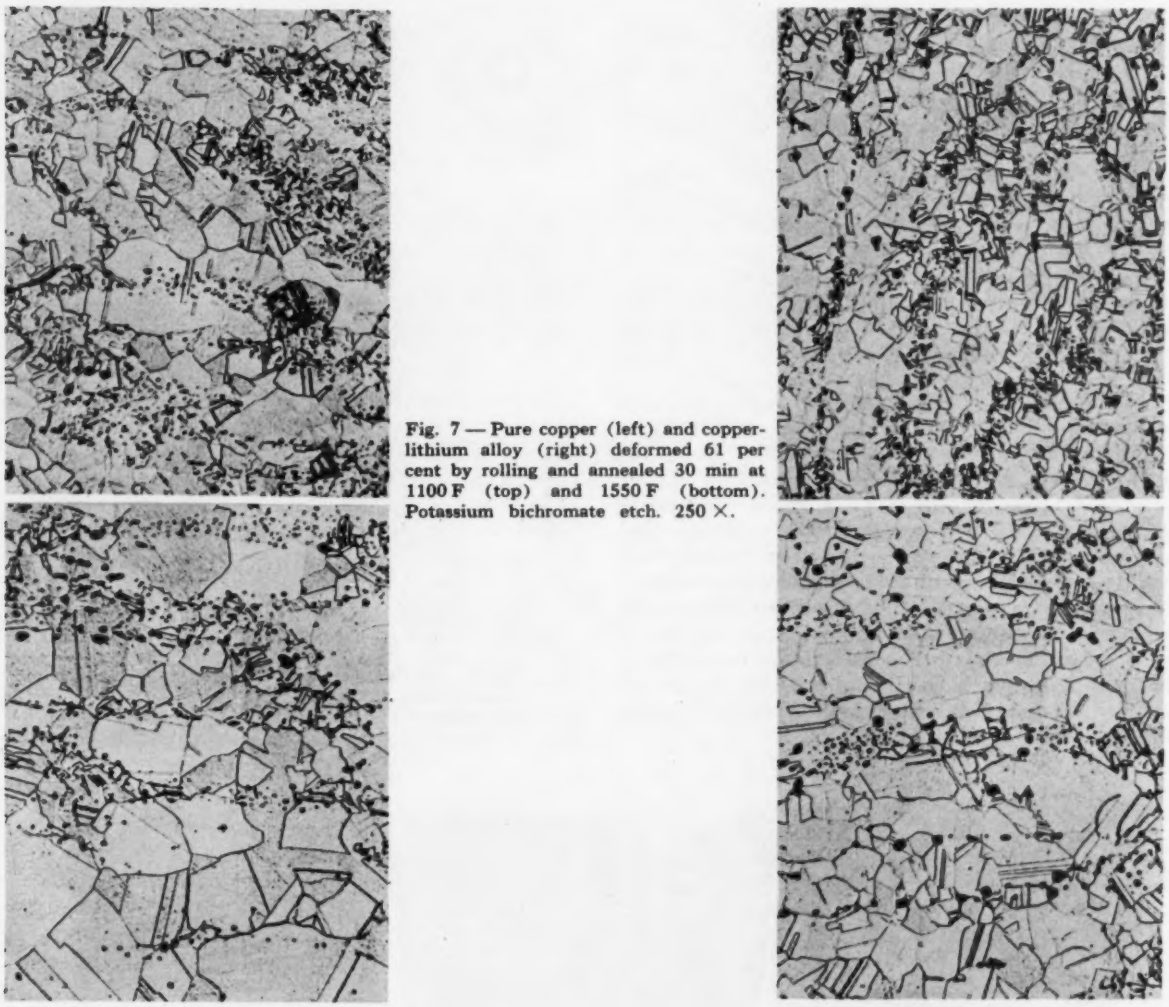


Fig. 7 — Pure copper (left) and copper-lithium alloy (right) deformed 61 per cent by rolling and annealed 30 min at 1100 F (top) and 1550 F (bottom). Potassium bichromate etch. 250 ×.

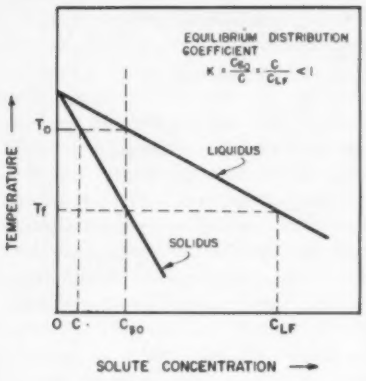


Fig. 8 (left) — Portion of a schematic binary phase diagram for eutectic type solute.

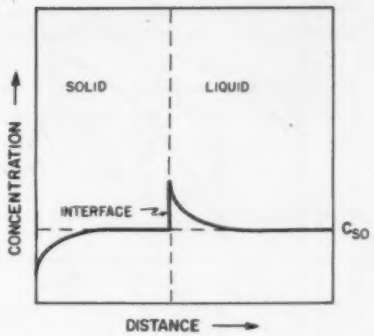


Fig. 9 (right) — Solute concentration adjacent to an advancing solid-liquid interface during alloy solidification.

Constitutional Supercooling

Grain growth restriction by means of constitutional supercooling is primarily associated with the difference in solute concentration in the solid and liquid phase during freezing. This can best be illustrated by considering the left-hand corner of the idealized binary phase diagram, shown in Fig. 8. An alloy of overall composition C_{so} begins to solidify by rejecting solid crystals of composition C. Under equilibrium condition the composition of the liquid, as well as that of the solid, is uniform and can be determined at any temperature in the freezing range by the respective tieline in the phase diagram (i.e., C_{so} and C_{LF} at T_F).

In practice, however, solidification proceeds at a rate faster than the diffusion rate necessary for the atoms to redistribute themselves. As a result, a concentration gradient will be formed ahead of the solid-liquid interface because of local enrichment of the liquid with solute. Since the liquidus temperature T_c is a function of composition, it must change with distance from the interface, in the manner shown in Fig. 9. In this figure, temperature distribution in the melt *d* is superimposed to show that under appropriate thermal conditions, the liquid immediately adjacent to the solid-liquid interface is "constitutionally supercooled."

A stage may be reached during freezing when constitutional supercooling is large enough to promote independent nucleation ahead of the interface, thereby allowing equiaxed grains to form ahead of the columnar zone. The prerequisite for this is that the maximum degree of undercooling, labeled ΔT_m in Fig. 10, be greater than ΔT_c, the critical undercooling required for the activation of nucleation. The compositional and thermal parameters promoting independent nucleation have been discussed in the introduction.

An alternate grain growth inhibiting mechanism to constitutional supercooling has been advanced, based on adsorption.[16] According to this hypothesis, solute atoms become adsorbed on the surface of a growing stable nucleus, thereby saturating the attractive surface forces exerted by the solid interface atoms on the atoms in the liquid. Consequently, further attachment of parent atoms becomes more difficult and growth of the existing crystals is reduced.

The grain growth restricting power of a solute element is proposed to be dependent upon whether its atoms have an "open" or "screened" electron configuration. The open configuration is supposedly effective, particularly if the valency of the element involved is high. According to this adsorption theory, suitable grain growth inhibitors can be selected on the basis of the electron configuration of free atoms.

Inoculation - Restriction Combined Action

The combined action of inoculation and grain growth restriction may be obtained in a peritectic system, and can be explained on the basis of the binary peritectic phase diagram shown in Fig. 11. When an alloy of composition *X* is cooled to slightly

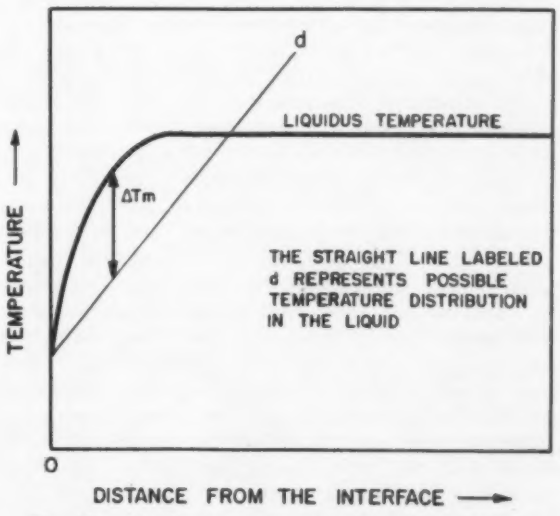


Fig. 10 — Liquidus temperature and possible temperature distribution in the liquid as a function of distance from the interface during alloy solidification.

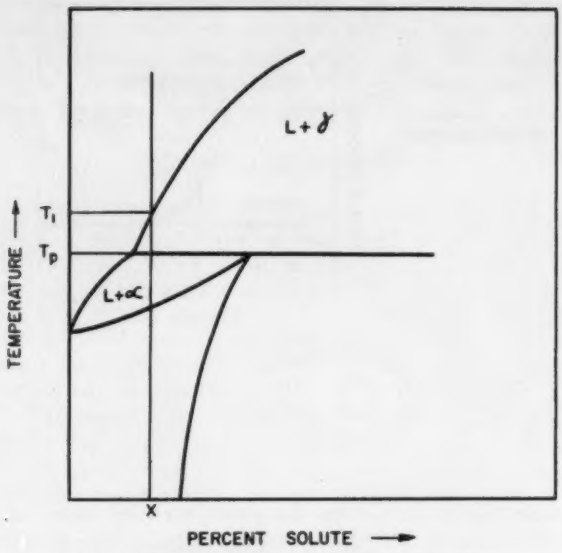


Fig. 11 — Schematic of binary peritectic reaction.

below T_l, a γ phase rich in solute will be separated from the melt. This phase reacts with the liquid at the peritectic temperature T_p to form the α phase.

The maintenance of this reaction requires solute atoms from the γ phase to diffuse through the α layer, while solvent atoms from the liquid must migrate to the enveloped γ phase. Consequently, this reaction proceeds rather slowly, thereby effectively reducing the growth of crystals in the melt. Moreover, the α phase surrounding the primary γ particles presents ideal sites for nucleation for the lower temperature α phase, whether the peritectic reaction goes to completion or not.

RESULTS INTERPRETATION

The experimental results obtained in this investigation may now be interpreted in the light of the principles outlined above. In the case where inoculants above were added to the base copper, significant grain refinement was achieved only with the metal powders (iron, cobalt and tungsten) and then only, when pouring from close to the melting temperature of copper. These results demonstrate clearly the importance of a shallow temperature gradient when inoculation is the governing grain refining mechanism.

Since all three powders are soluble in liquid copper, it is conceivable that they partly dissolved and thus assisted, together with other soluble impurities present in the melt, in producing sufficient constitutional supercooling for independent nucleation ahead of the solid-liquid interface. Also, the good crystallographic registry of iron, cobalt and tungsten with copper helped to facilitate rapid nucleation, once the appropriate thermal and compositional conditions were established near the interface.

High superheating and pouring temperatures dissolved more of the inoculants in the melt and increased the temperature gradient. It is hypothesized that this higher thermal gradient reduces both the number of available nuclei, and the degree of constitutional supercooling which could be achieved despite a higher solute concentration.

Lithium and Bismuth Effectiveness

The effectiveness of lithium and bismuth in producing fine, equiaxed grains must be attributed to their marked constitutional supercooling potency, as evidenced by a large freezing range and low distribution coefficient. The degree of supercooling achieved with these two elements is evidently sufficient to allow independent nucleation ahead of the solid-liquid interface to occur. Since in these cases no inoculating agents were added, it is assumed that impurities present in the base metal act as centers of heterogeneous nucleation.

The failure of calcium and magnesium additions to produce grain refinement suggests that the constitutional supercooling, which can be achieved with these solute elements when added in small quantities, is insufficient to activate nucleation of the impurities present in the base metal. The relatively small freezing range and the comparatively high distribution coefficient, typical for the respective alloys studied, lend support to the above interpretation.

The reasons for the inefficiency of lead in producing fine, equiaxed grains are not readily apparent, particularly since small lead additions produce a large freezing range. As far as the difference in solute concentration in the liquid and solid is concerned, it should be observed that this difference is relatively small when expressed in terms of atomic per cent lead, the important consideration.

Thus, for a given freezing rate, the solute buildup at the solid-liquid interface is less than for equivalent weight per cent additions of lithium and bismuth. Also, the large freezing range of over 700 F is somewhat deceptive in view of the particular monotectic reaction of the Cu-Pb system. The formation of a secondary liquid, rich in solute, depletes the remaining bulk liquid and therefore tends to counteract the solute buildup at the solid-liquid interface.

This depletion also raises the liquidus temperature of the bulk liquid, thus favoring the continued growth of the already existing crystals. This behavior is the opposite of that encountered in peritectic systems, where the formation of a solute rich particle occurs which also results in the depletion of the remaining liquid. However, the liquidus temperature in this case is lowered and effective constitutional supercooling is promoted.

Monotectic Reaction

The exact nature of the effect of the monotectic reaction on solidification has not yet been established. It will undoubtedly depend upon the rate of freezing because of the importance of the diffusion processes involved. The literature provides evidence[15] that a 5 weight per cent addition of lead can produce grain refinement in copper-base alloys. This amount exceeds

appreciably the maximum amount of lead (1 weight per cent) added in this investigation.

Consequently, more grain refinement would be expected because of the greater concentration of lead-rich liquid at the solid-liquid interface. However, the amount of refinement reported for a 5 weight per cent lead addition is less than that achieved with much smaller amounts of lithium or bismuth in this present work.

The results obtained by dissolving iron and cobalt in liquid copper at least suggest that the occurrence of the peritectic reaction may be of considerable importance in producing fine grains. Additions less than those required to produce the peritectic reaction on cooling did not exert any effect on the as-cast structure. On the other hand, dissolving 2.42 weight per cent iron resulted in exceedingly fine equiaxed grain.

Iwase, Asato and Nasu have demonstrated[20] the importance of the peritectic reaction in the binary Cu-Fe and Cu-Co systems as well as the Cu-Sn, Cu-Si, Cu-Zn, Ag-Cd, Ag-Zn, Sn-Sb and Al-Ni systems. In all cases, the grain size plotted versus percentage solute shows a marked inflection at or near the concentration necessary to undergo the peritectic reaction. The resulting grain size is definitely refined by each of these hyperperitectic concentrations.

No explanation can be advanced for the failure of tellurium and selenium to restrict columnar grain growth. The fact, however, that these two elements were unsuccessful may be taken as an indication that effective grain growth inhibitors cannot be selected on the basis of a given feature characterizing the electron configuration of the free atom alone.

CONCLUSIONS

The as-cast grain size of electrolytic copper was appreciably refined to approximately 0.250mm average grain diameter by the addition of lithium and bismuth, separately and in combination, to the melt. The additions made were approximately 0.50 per cent by weight, but a much larger percentage of bismuth than lithium was retained. This grain refinement was attributed to the constitutional supercooling produced by these elements, and their success is believed to be associated with the large freezing range (liquidus-solidus spread) of alloys of copper with lithium and bismuth.

The grain refinement of cast copper by the solution of considerable amounts of iron in the melt before solidification, as reported by previous investigations, was confirmed. This refinement reduces the average as-cast grain diameter to approximately 0.10mm. The effectiveness of iron is attributed to the peritectic reaction. Iron in smaller amounts than necessary to obtain the peritectic reaction did not produce grain refinement.

Numerous other additions to copper melts were ineffective in refining the cast grain. These additions included numerous intermetallic compounds supposedly effective as inoculants; lead, calcium and magnesium that were selected to produce constitutional supercooling, and the elements selenium and tellurium intended to restrict grain growth by adsorption on the surface of growing copper crystals. Metal powder additions were only effective as grain refining inoculants at low superheat.

The effective grain refiners, lithium and bismuth, produced some improvement in tensile properties and raised the grain coarsening temperature, but decreased the electrical conductivity.

ACKNOWLEDGMENT

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LOW PRESSURE DIE CASTING

by E. C. Lewis

ABSTRACT

The system of low pressure die casting, described as a flow method against the force of gravity with slow cooling to complete solidification is described by the author. Illustrations showing equipment used are appended to the article.

HISTORY

This system can be described as a flow method against the force of gravity with relatively slow cooling to complete solidification. The need for such a process was created prior to the last war to produce castings of high quality, and to avoid the necessity for machining, thereby saving overall labor hours in producing the finished product.

The possibility of producing castings by this method was a development from the low pressure furnace for magnesium that was introduced in 1937. This furnace permitted magnesium to be melted under an inert gas and, when molten, to be extracted by means of an acute angled tube that passed through the top cover of the furnace. When pressure was created inside the furnace, the metal was forced upwards through the tube on to an open chute for decanting into a ladle.

This type of furnace was used exclusively during the last war for the bulk melting of magnesium and for the production of a variety of castings, chiefly in connection with incendiary bombs. Three companies in Great Britain collaborated together to produce castings that could replace forgings for the aircraft industry, thereby saving machining hours. This casting process was developed to make it possible to produce castings for air-cooled cylinder heads that did not need more than 2 per cent of the machining time spent in completing them than by the earlier method of solid forgings and formation of fins by milling.

The production of castings in those days was longer in terms of pieces cast per hour than the permanent mold system for a casting of the same weight. However, the immense saving in machine tool capacity, and labor hours in machining, made the finished product an economic proposition in units produced per man-hour.

At the end of the war, owing to the fact that as a casting system it was not as fast as permanent mold practice, it was abandoned by the three companies who had used the system for war production.

It was deemed by one of the Engineers, who was instrumental in this war development, that improvements could be made in the system, not only to compete with the permanent mold method, but to widen the range and type of castings that could be produced in aluminum and its alloys. For this purpose the author's company was formed, and markets entered that were new to the casting trade. The first market being the production of a wide range of aluminum holloware goods for both domestic and canteen use. This was quickly followed by entering the domestic rainwater goods trade in competition with iron, which has continued to increase every year. A completely new departure was pioneered in the production of cast aluminum barrels, first for the beer trade and then spreading into other trades in competition with oak or other classes of hard wood.

At the same time as this pioneer work was being developed, experience proved that the method could be used to satisfactorily compete with the permanent mold method where pressure tightness of a casting was of first importance. Later it was possible to spread into the furniture and light machine trade, such as textile looms, where reciprocating weight, as well as soundness of product, could be used with advantage.

It would not be right to leave this brief and condensed history without stressing the point that no system of founding has yet been developed that suited every type of casting that is required. As far as aluminum and its alloys are concerned the low pressure system will ultimately be the most popular, but for certain classes of work it will never be able to displace high pressure casting, slush casting or, for certain sizes of work, gravity or permanent mold casting.

OPERATION

The operation is to hold molten metal in a hermetically sealed crucible and expel the molten metal upwards from the crucible through a tube (similar to the principle of a soda-water syphon) into the base or lowest convenient point of a permanent mold. The pressure is maintained after the mold is filled to permit the feeding of the casting in an upward direction against the force of gravity. This is the reverse of the permanent mold method wherein a heavy

E. C. LEWIS is Managing Dir., Alumasc Ltd., Northamptonshire, England.

riser is used to carry metal in a liquid state for a longer period than the solidification of the casting proper and feed the heavy sections by force of gravity.

One advantage of the low pressure method lies in the fact that the temperature of the permanent mold, due to its position during the casting operation, is nearly twice as hot as the accepted temperature used for gravity permanent mold work. This permits a longer period of time for feeding to take place, and thereby produces a sounder casting than is usual with gravity feeding. The pressures used vary with the height and weight of the casting. A minimum figure would be 2½-lb/sq in., and a maximum figure of 10 lb/sq in.

Experience has shown that if the permanent mold is mounted directly on top of the plate that is used to seal the crucible, there will be a definite period of time for each casting, over a reasonably wide range of metal temperature, where the metal in the tube, transporting the metal from crucible to mold, will remain molten, and the neck or ingate adjacent to the runner will solidify. It is at this point that the pressure in the crucible is released, and the column of liquid metal in the tube drops back permitting the casting to be extracted.

Because this system of feeding is upwards in place of downwards risers are not required. Large quantities of castings have been produced weighing over 80 lb per piece, with relatively heavy rims or bosses in the upper portions that are equally sound with the rest of the casting.

MATERIALS AND METALS

The most suitable material, when all factors are taken into consideration, for the mold, top plate and crucible, is good quality soft gray iron. This gray iron maintains its shape for long periods, despite consecutive heating and cooling, is economical to produce and machine and can be protected by dressing on those portions that come in contact with molten metal. The portion of the crucible containing the metal must be graphite, plumbago or other proved refractory that does not affect aluminum or its alloys.

The tube transporting the molten metal from the crucible to the mold, if manufactured in cast iron, must be suitably protected by dressings against erosion, otherwise refractory materials such a silicon carbide, must be used, and works precautions against damage instituted and maintained.

Ancillary equipment to facilitate the withdrawal and reassembly of the mold portions are similar in every respect to those used in permanent mold and high pressure work.

From the description given above, any experienced foundryman in aluminum alloys will realize that alloys that solidify sharply and are difficult to feed, are not satisfactory for this method of casting. This excludes alloys having a high copper or zinc content, and favors alloys having a magnesium and silicon content. For general purpose work the most satisfactory alloy is one containing approximately 11 per cent of silicon, and other metals only by impurity (grain refiners excepted) and where high elongation is permitted the inclusion of magnesium is recommended, without any special precautions being taken, up to 4/5 per cent.

It will be appreciated that these details are a generalization, and variations can obviously be made to suit any particular application.

DIE DESIGN

This is a wide subject that it is difficult to generalize, each casting having to be taken on its merits. However, the aim, outside structural strength, is to so design the mold that cooling starts first at the point farthest away from the ingate, and continues progressively until reaching the ingate, which is the dividing line between the liquid metal and the casting immediately prior to extraction. The portions of the mold that are thick in section have a chilling effect, and portions of the mold that are thin in section have a heating effect. This is due to the fact that they absorb less heat and allow free passage for a longer period for the metal to flow before solidification.

Where strength is required, either for die manipulation, or to correct distortion it is advisable to fix, by bolting or like method, such supporting pieces to the mold. This is because any break, even when the adjacent piece is well machined and bolted to the mold, constitutes a drop of from 25 to 50 per cent in the heat gradient.

Multi-cores can be used, provided the joints approximate to 90 degrees, and a slight lead is given to one part over the other to facilitate withdrawal.

Wherever practical the height of the mold should be reduced to a minimum and the ingate applied to the heaviest portion of the casting. Inserts to effect progressive cooling can be made from copper plugs. The section of the mold can be varied to have the larger wall adjacent to the heavier thickness of the casting to be produced. The locking of the mating portions of the mold can most conveniently be arranged by cams, solid or slotted. Any withdrawal aids that are applied should be removed from the mold itself to operate under as cool conditions as practical.

The design of the mold should permit, in principle, the casting to be extracted from the mold with the aid of the core. After the core has performed that function it should be extracted by any suitable mechanical means that gives sufficient mechanical advantage, the re-action to this pressure being afforded normally by a stripping plate. This usually encompasses the print of the core and forms the upper portion of the casting.

DIE DRESSING

This is similar to die design inasmuch as it is difficult to generalize, since each type of casting calls for variation in the dressing used. The most common dressings are a mixture of chalk (calcium carbonate), with an addition of water-glass (silicate of soda) as an adhesive. The surface of the mold against which the metal has to impinge should be rough-

ened, similar to the finish obtained by the application of emery cloth or shot-blasting. Small additions of boric powder will be found advantageous in absorbing super-heated moisture and preventing the formation of gas bubbles, which in turn can create small blow-holes.

Where it is desired to have free flow of metal, the dressing should be thickened by more than one application. Where it is necessary to accelerate cooling, the dressing should be thin or even bared down to the iron surface to accelerate the transfer of heat.

The application of dressing to the mold is a practiced and, one might almost say, a skilled operation. Mold vents should not be clogged, and mating portions of the mold that do not form the actual surface of the mold should be kept clear and free of dressing. This is to maintain casting dimensions and act as a vent, since it will be apparent that the rate at which the mold can be filled with molten metal depends entirely upon the rate at which air can be expelled from the mold.

Mating portions of the mold that do not form the mold surface, core prints, stripping plate prints, the base of the sliding portions of the mold, etc., should be lubricated with a thin application of adhesive graphite that is common practice in permanent mold operation. Where core tapers are narrow and the contraction of the casting is severe, applications of graphite can be made on top of the standard dressing referred to previously. This application is to act as a lubricant and facilitate the withdrawal of the core from the casting.

The function of the dressing is to protect the inflowing metal from giving up its heat too quickly. This permits adequate feeding as well as steadies the flow of the metal, prevents one part of the casting being made at a higher level than the other during the flowing operation and imparts a uniform texture to the surface of the casting.

For these reasons it is not possible to obtain the smooth surfaced finish on the casting surface that is usual with high pressure casting, but it is possible to maintain a higher standard of smoothness that is normally accepted with a permanent mold casting of the same type.

ADVANTAGES AND DISADVANTAGES

As mentioned previously, there are certain types of castings that will always be produced more economically by gravity or permanent mold systems. These are, broadly, where changes of section are severe, such as 3/16-in. to 3/4-in. and back again to 3/16-in., or where the copper or zinc contents are higher than the magnesium or silicon elements, etc. Excluding this range, castings calling for sand cores, or multipart metal cores, are not so suitable due to the penetration of metal between the print joints or sections of a builtup metal core. These shortcomings entail delays in operation, loss of mold heat and uplift in scrap percentage.

Taken over a range of work the cycle time is longer, and operational corrections that occur in practice like freezing up of the ingate, nonmetallic accumulations in the runner stem, spillage through inadequate operational locking of the mold, etc., to name leading items, all take longer to clear and restart than is customary with gravity or permanent mold work.

The two foremost gains are metal ratio and soundness of product. It is usual in gravity or permanent mold work to have to melt 2½ to 3 times as much metal as that required for the casting only. This is due to runners and risers, etc., taking a range of castings from ¼-lb to, say, 5 lb. Whereas, by low pressure the weight of excess metal (excluding flash) on castings from ¼-lb to 70 or 80 lb does not amount to more than ½ to 2 oz.

Greater soundness is obvious, due to the longer feeding time and higher die temperature.

Smaller gains are lower initial mold costs, more consistent dimensional accuracy of production runs, cooler operating conditions and greater ease in applying automatic mechanical control of casting and mold operation.

In England long runs of castings are not so prevalent as in U.S.A., so the call for mechanical aids in cycle operation are not so great. However, automatic timing of flow and mechanical aids for mold separation and casting extraction are all matters for individual consideration according to demand.

METAL HOLDING

The low pressure system involves holding molten metal for a period to give economic runs between refilling the crucible. Where these periods are short, i.e., 1 to 2 hr, iron crucibles suitably treated with a protective coating similar to that described above, are suitable. However, where longer periods or shift-working, constituting much longer periods, or 24 hr working, is contemplated, it is essential to use plumbago or a similar refractory.

Because such crucibles are not safe to withstand even the low pressures involved, the writer evolved a double-crucible for use with an electric induction furnace, whereby the pressure imposed to operate the mold was applied equally to the inside, as well as the outside of the crucible. This involved no equipment strain other than mild compression on the walls of the refractory crucible. This method can only be used satisfactorily with an induced electrical field, relying upon the cure point of the cast iron outer shell to maintain heat at an economical rate in the liquid metal. At the same time the iron shell takes the entire stress imposed by the pressure used, as well as a basis for an adequate seal to operate the system.

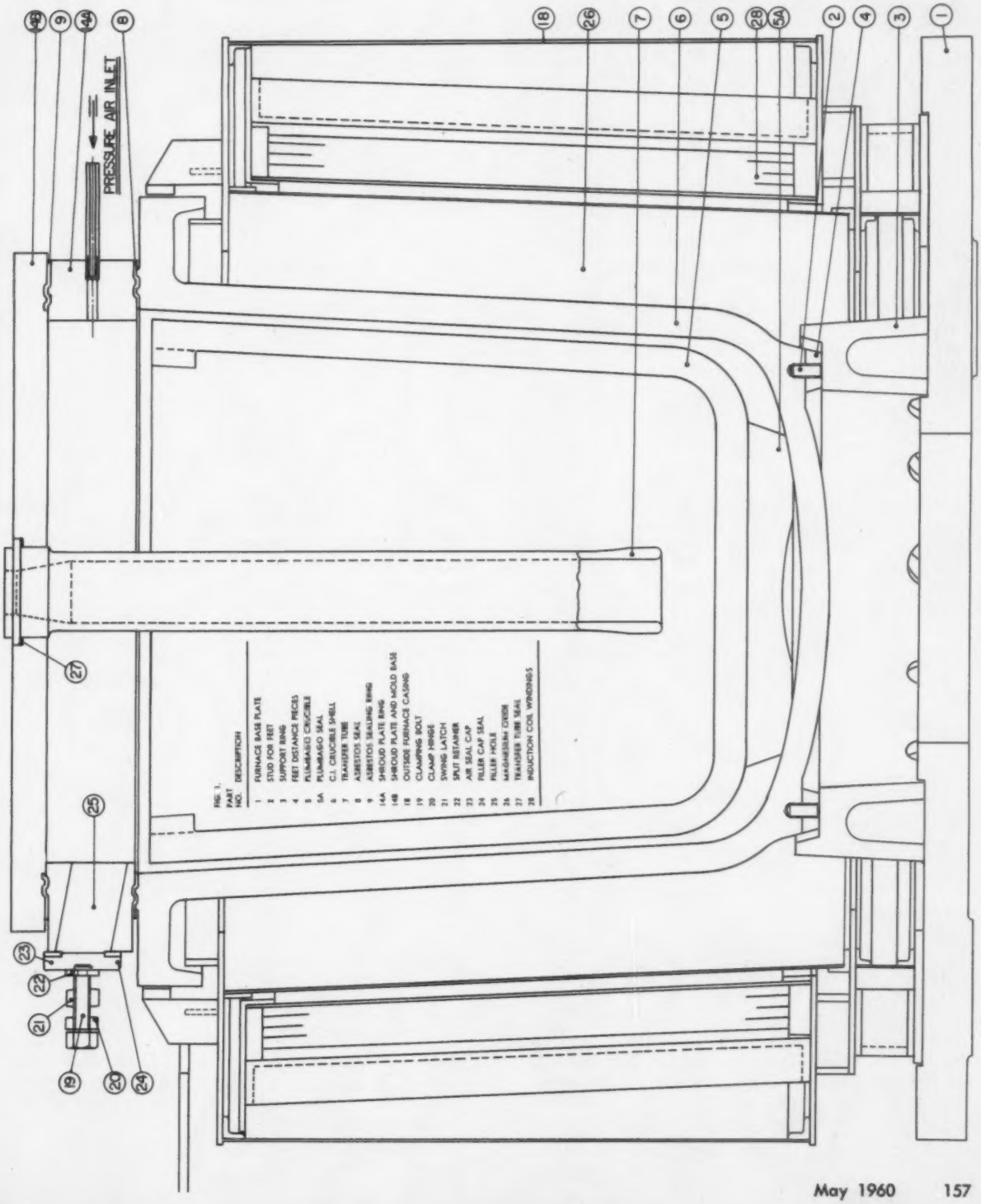
ILLUSTRATIONS

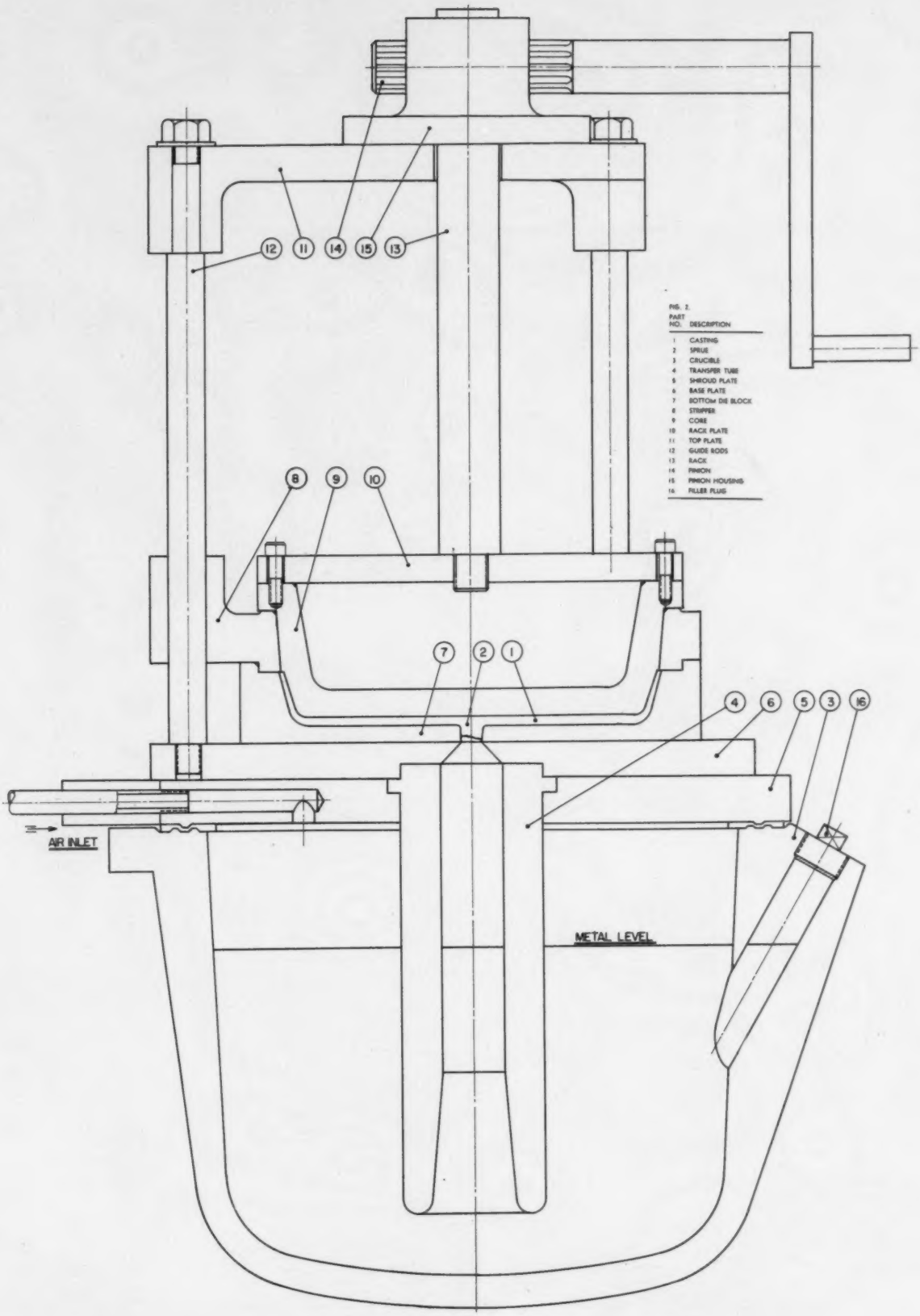
Because this short article on a wide and, as yet, partially developed subject may be more readily understood, illustrations showing a simple die mounted on a gas-fired iron crucible of limited capacity (90 lb), and another on an electric induction furnace of 750 lb are attached (Figs. 1 and 2). The details can easily be followed from the numbered guide.

Although low pressure die casting has been prac-

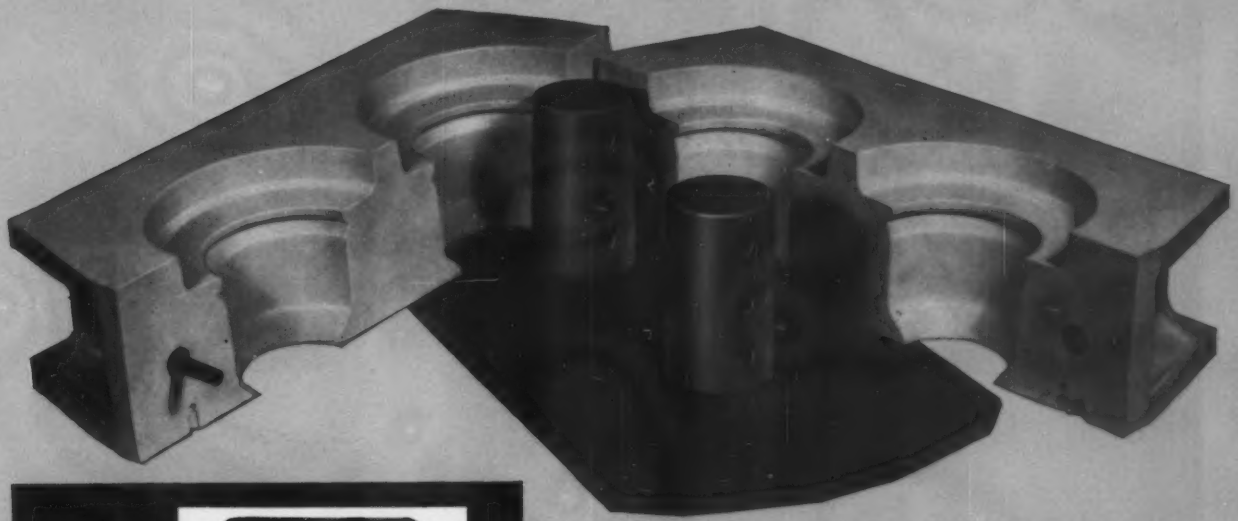
ticed by the author's company with continued growth over the last 15 years, it has only become generally accepted during the last 5 years. It is now being used in a limited way in Austria, Germany, France and last year in U.S.A. by an automobile producer. In England it is used for the production of rainwater goods, looms, furniture, pressure fertilizer and paint equipment, street lighting, etc., and to the greatest extent in pressure casks for the brewery trade which has now grown to the largest of its type in Europe.

Like all other casting processes much depends upon usage, often termed "know-how," or practice on the floor of the shop. This is quality that cannot be imported by writing, but is all-important in valuation between success and failure, judged economically or by value of the product.

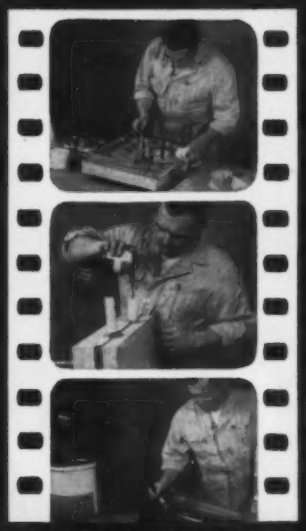



FIG. 2.
PART NO. DESCRIPTION
1 CASTING
2 SPRUE
3 CRUCIBLE
4 TRANSFER TUBE
5 SHROUD PLATE
6 BASE PLATE
7 BOTTOM DIE BLOCK
8 STRIPPER
9 CORE
10 RACK PLATE
11 TOP PLATE
12 GUIDE RODS
13 RACK
14 PINION
15 PINION HOUSING
16 FILLER PLUG
12
11
14
15
13
8
9
10
7
2
1
4
6
5
3
16
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90,000 CORES–
ONLY .010" OF WEAR!



Here is a typical example of the excellent wear characteristics of EPOXICAL plastics by U.S.G. Over 90,000 cores were blown in this laminated core box shown here in open view. Inspection by the pattern shop after production run revealed there had been only .010" wear on the lower radius or flange surface which was directly under the blow tubes.



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- ☐ HYDROCAL*—ULTRACAL* Gypsum Cements Bulletin No. 102
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Your castings carry your reputation...

it pays to find cracks before your customers do

No matter how carefully you control pouring, handling or other processing, cracks and other "invisible" defects are likely to appear in *some* of your castings. You owe it to yourself to find trouble makers as quickly, efficiently and economically as possible.

Not all cracks need rejection—or repair. But cracks in high stressed areas of parts are very serious. Extremely small cracks can cause early failure, if highly stressed!

First, finding all such defects early eliminates bad castings before they go to your buyer or before time is wasted in your own machining or assembly operations.

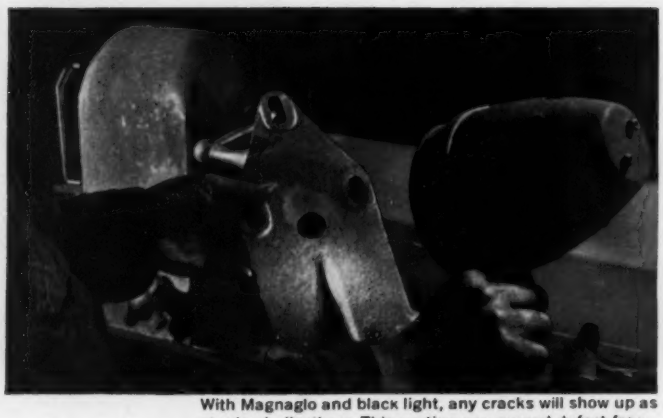
Second, even *more* important—a defective casting carries with it your reputation and your best chance for repeat business. Can you afford to wait for your customers to test your product for you—especially when you can identify any important defects so easily and economically with Magnaflux Test Systems?

Third, reliable quality is your own best protection against possible conversion from your castings to other means of fabrication. Consistent quality is "job insurance."

Magnaflux testing for magnetic metals and Zyglo for nonmagnetics are easy to use, positive and can save far more than they cost. The critical flaws you need to find appear directly on the part—actually glow with Magnaglo or Zyglo.

Magnaflux-Magnaglo and Zyglo fit into your operations at any point...wherever and whenever this will save you the most money to find and correct the cause of the defects. Many foundries now install Magnaflux or Zyglo "check-points" along their processing set-up to insure the quality and profits of their output—start to finish. For gray iron tests, the $195.00 type Y-5 yoke kit proves extremely useful.

Regardless of the size or kind of castings you make, from ounces to tons, a Magnaflux Nondestructive Testing Engineer can help you meet your planned requirements—for quality, cost—even market expansion. Ask to have him call soon...meanwhile write for data and case studies.



With Magnaglo and black light, any cracks will show up as glowing indications. This casting was proved defect-free.

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For magnetic metals. Prices from $195.

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news and views

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How Technical Committees Operate Is Illustrated by Sand Division Group

How committees of the various technical divisions operate is typified by the Grading, Fineness & Distribution Committee of the Sand Division which met during January in Chicago.

Objectives of the committee are:

- AFS standard clay determination.
- Testing for combustibles in sand mixtures.
- Testing for sieve analyses of granular foundry material such as seacoal, pitch, bentonite, fire clay and cellulose material.
- Methods of handling sand relative to segregation characteristics.
- Revising past methods of testing particle size of core and mold material.

Projects are underway at the present time on seacoal, clay test procedures and sampling. These are progressing as follows:

Seacoal—Work is being done on seacoal containing dust suppressant material. Several solvents have been used as a means of dissolving the dust suppressant. A preliminary report is to be made to subcommittee members with samples of a seacoal to be considered as a standard with the request that further work be done on the project.

Clay Test Procedure—Report has been prepared covering experiments on clay determination as conducted using synthetic sand mixtures of bentonite and silica sand (without carbonaceous material). The next report will cover similar tests on sands containing other additives (compounded sand mixtures). Samples will be prepared and sent to cooperating committee members for testing.

Sampling—Tests made on segregation of sand in cars after loading apparently show that segregation did not occur in transit. Tests were run using dyed sand, and no movement of this material occurred except at ends of the car and a little at the sides. Sampling at destination indicated that at least under conditions of the test, the sand did not segregate materially in transit. It appears that differences in sand analysis at the source and receiving foundry, appear to be due to errors resulting from the method of sampling. It was agreed that similar tests will be conducted with results to be announced at the next meeting.



Members of the **Malleable Division Casting Design Committee** meeting in Chicago during March, left to right: AFS Technical Director **S. C. Massari; John Flitz,** Central Foundry Div., GMC; **Jack Caine,** consultant, Cincinnati; **J. W. Beckham,** Texas Foundries, Inc.; **Robert Johns,** Belle City Malleable Iron Co.; **R. J. Franck,** Superior Steel & Malleable Castings Co.; **Russell Baker,** Albion Malleable Iron Co.



Japanese cast steel manufacturing team, sponsored by the Japan Productivity Center, visited AFS headquarters in April. The team, under the auspices of the International Cooperation Administration, visited American manufacturers and trade associations during March and April. The men observed production techniques including such operations as molding, sand preparation and reclamation, heat treatment, welding, materials handling and quality control.

AFS-TRAINING & RESEARCH INSTITUTE 1960 EDUCATIONAL COURSES

JUNE—SEPT.

Subject and Description	Dates	Course Length (Days)	Where Given	Course Fee
Production of Ductile Iron	**June 27-29**	**3**	**Chicago**	**$60**
Melting equipment and melting practices are emphasized for lowering production costs. All phases of production are presented—metallurgy, inoculants, quality control, pouring practices, raw materials and inspection methods. Specialized course for all foundry personnel producing ductile iron or contemplating entering this casting field. **Course No. 7**				
Blue Print Reading, Estimating	**July 11-13**	**3**	**Chicago**	**$60**
Basic fundamentals and principles necessary when considering new jobs. Job analysis techniques are presented in logical step-by-step procedure . . . including the initial reading of blueprints to production planning Practical methods of estimating new jobs are studied, emphasizing "danger points" which can increase production costs. This course covers information which is vitally important for economically successful foundry operations. Key personnel involved in these responsibilities can learn new techniques. **Course No. 8**				
Welding and Brazing of Castings	**Aug. 17-19**	**3**	**Chicago**	**$60**
Practical analysis of when and how to repair ferrous and non-ferrous castings. Equipment, new methods, filler rod alloys, new techniques and applications. Welding and brazing technology as it relates to castings and the fabrication of component castings with wrought materials. Metallurgy, mechanical properties and heat treatment of parent and weld metal will be discussed. **Course No. 9**				
Core Practices	**Aug. 29-Sept. 2**	**5**	**Chicago**	**$90**
Concentrated core instruction for foremen, sales engineers, supervisors, technicians, engineers and management. All aspects of materials, mixing and sand testing, economical application, advantages and limitations of new processes and materials are studied. Casting losses attributed to cores are analyzed for solutions. Case problems are welcomed for class discussion. **Course No. 10.**				
Foundry Refractories	**Sept. 12-14**	**3**	**Chicago**	**$60**
Intensive specialized instructive course providing informative, up-to-date technology on foundry refractories. Materials, lining techniques, typical applications. Emphasis on types, selection, use, maintenance and economy in foundry practices. Course provides broad understanding of these expendable foundry materials and how their intelligent use can reduce operating costs. Course designed for supervisors, foremen, technicians, engineers and management. **Course No. 11**				
Economical Purchasing of Foundry Materials	**Sept. 26-28**	**3**	**Chicago**	**$60**
Course gives detailed instruction on the intelligent buying of scrap, refractories, sand, alloys, binders, core oils, additives, etc. Purchasing decisions should be based on all factors, including costs to the point of consumption in the plant. Up-to-date information on all aspects of foundry materials purchasing. Valuable to supervisors, engineers, purchasing agents, foremen and management. **Course No. 12**				

REMAINING AFS-T&RI COURSES FOR 1960

Sand Testing		**$150**
Course No. 13	Oct. 10-14	Detroit
Foundry Plant Layout		**$60**
Course No. 14	Oct. 24-26	Chicago
Metallurgy of Light and Copper-Base Alloys		**$60**
Course No. 15	Nov. 7-9	Chicago
Sand Control & Technology		**$60**
Course No. 16	Dec. 5-7	Detroit

REGISTRATION NOW OPEN. Make reservations for all 1960 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received at AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill.



Members of the **Ductile Iron Research** Committee meeting in Chicago. Guest, **N. N. Sacks,** Deere & Co.; **M. H. Horton,** Deere & Co.; **D. L. Crews,** James B. Clow & Sons; **H. W. Ruf,** Grede Foundries, Inc.; AFS Technical Director **S. C. Massari; A. W. Anderson,** International Harvester Co.; **H. G. Haines,** Woodruff & Edwards, Inc.; **W. M. Spear,** Worthington Corp.



Members of the **Cupola Advisory Committee** at their March meeting in Chicago. **C. F. Joseph,** Central Foundry Div., GMC; **H. N. Bogart,** Ford Motor Co.; **H. A. Deane,** Campbell, Wyant & Cannon Foundry Co.; **H. H. Wilder,** Vanadium Corp. of America; **B. I. Stern,** Lakey Foundry Corp.; **David Matter,** Ohio Ferro-Alloys Corp.; **J. E. Rehder,** Canada Iron Foundries, Ltd.; **R. Bauer,** Acme Steel Co.; **M. D. Neptune,** National Works, James B. Clow, & Sons; **Ralph Carlson,** American Cast Iron Pipe Co.; **W. W. Levi,** consultant; **R. A. Clark,** Union Carbide Metals Co. Div., Union Carbide Corp.; **M. H. Horton,** Deere & Co.; **D. E. Krause,** Gray Iron Research Institute; **H. W. Lownie,** Battelle Memorial Institute; **W. R. Jaeschke,** Whiting Corp.; **H. W. Gorman,** Allis-Chalmers Mfg. Co.; AFS Technical Director **S. C. Massari.**



Members of the **Malleable Research Committee** met in February in Chicago. Shown are: **Carl Joseph,** Central Foundry Div., GMC, Saginaw, Mich.; **J. H. Lansing,** consultant, Shaker Heights, Ohio; **P. F. Ulmer,** Link-Belt Co., Indianapolis; **J. Widmoyer,** University of Wisconsin; **C. R. Loper,** University of Wisconsin; **R. W. Heine,** University of Wisconsin; **Eric Welander,** John Deere Malleable Works, East Moline, Ill.; **W. D. McMillan,** International Harvester Co.; **W. K. Bock,** National Malleable & Steel Castings Co., Cleveland; **R. P. Schauss,** Werner G. Smith, Inc., Chicago; **S. C. Massari,** AFS Technical Director; **E. J. Stockum,** Dayton Malleable Iron Co., Dayton, Ohio.

A. E. Falk New AFS Director

A. E. Falk, general manager of Centrifugal Casting Co., Long Beach, Calif., has been nominated AFS National Director from Southern California. Falk's selection was made by the Society's Board of Directors following withdrawal of the original nominee announced in the January issue of MODERN CASTINGS.

Core Test Group Conducts Workshop

A two-day working committee meeting was held Feb. 25-26 at the University of Illinois by the Sand Division Core Test Committee for the setting up of standard procedures for evaluating silicate bonded sand mixtures.

Six different sand mixtures were prepared: lake sand with 3 and 5 per cent binder; silica sand with 3 and 5 per cent binder; 75 per cent lake sand and 25 per cent bank sand with 3 and 5 per cent binder.

The regular 2x2 in. standard sand specimen, rammed according to standard procedure was used for one series of tests and gassed at 15, 30 and 50 sec under 10, 20, 30 and 40 psi.

The standard tensile core test rammed according to standard procedure was used for another series of tests and gassed at 15, 30 and 45 sec at 10, 20, 30 and 45 psi.

Gassed shear strength was determined on all 2x2 in. specimens; the gassed tensile strength was determined on core tensile specimens. In addition, a series of hardness tests was made on all specimens.

Approximately 1500 determinations were made. All materials needed for the tests were furnished free by various companies. The only expense involved was the labor required to set up and take care of all the necessary equipment. This work was done by Norman Donze, a mechanic in the university foundry.

W. H. Buell, Aristo Corp., Detroit, was nominated as chairman of the committee and Prof. C. E. Schubert, University of Illinois, as vice-chairman. The new officers will assume their duties following the annual Convention.

Students to Operate Foundry at Exposition

A working foundry occupying nearly 1000 sq ft and operated by 20 students of the Murrell Dobbins Vocational-Technical School of Philadelphia will be one of the features of the AFS Exposition, May 9-13 at Philadelphia.

Students will make souvenir castings for Exposition visitors performing all operations from sand testing through shakeout and finishing. All necessary sand, metals, molding machines, pattern equipment, tools and melting furnaces are being furnished as follows: sand by Geo. F. Pettinos, Inc., Philadelphia; molding machines by International Molding Machine Co., LaGrange Park, Ill.; sand cutting machine by Royer Foundry & Machine Co., Kingston, Pa.; patterns by Philadelphia Matchplate Co.

Special shirts with the words "Dobbins Foundry" on the back will be furnished by the AFS Philadelphia Chapter which is also jointly sponsoring the exhibit with the school.

The Murrell Dobbins School, part of the Philadelphia school district, was founded in 1938 and offers 28 separate vocational courses, including foundry practice. The school foundry occupies a new modern annex and is equipped with 16 bench-molding stations, floor molding, two gas-fired non-ferrous furnaces, a cupola, cut-off saw, grinding and shotblast equipment and three core ovens. Other facilities include a sand testing laboratory, CO_2 equipment and storage bins for sand, coke and metals.

Boys who take the foundry courses at Dobbins spend three hours daily in the shop, receive a high school diploma on completion of their course, and may take foundry practice in a ninth-grade "trade exploratory" course. The entire school, at Lehigh Ave. and 22nd Street, will be open to visitors daily during the Castings Congress and Exposition.

Ontario Gives T&RI Course

Basic principles of gray iron metallurgy were presented in a three-day course, March 16-18 at the King Edward Hotel, Toronto, Ontario, cosponsored by the AFS Ontario Chapter and the AFS Training & Research Institute. This is the third AFS-T&RI course presented by the Ontario Chapter.

Instructors were: Prof. W. L. Womochel, Department of Metallurgical Engineering, Michigan State University, East Lansing, Mich.; Harold E. Barnum, Vanadium Corp. of America, Detroit; T&RI Director S. C. Massari and T&RI Training Supervisor R. E. Betterley.

On the opening day, subjects covered included the alloy phase diagram and its interpretation, solidification of an iron-carbon-silicon alloy, chilling tendency and its determination, composition and microstructure. Thursday's sessions consisted of a study of inoculation, relation of carbon equivalent to mechanical properties of gray iron, the effect of superheating during melting, section sensitivity of gray iron and improvement of gray iron through use of alloys. On the concluding day, gray iron microstructure was studied during the morning; the afternoon session included an achievement test and course evaluation.

The course designed for melters, metallurgists, engineers, researchers, supervisors and management was attended by 37 foundrymen from the provinces of Ontario and Quebec, as well as seven states south of the border.



Inspecting castings at the AFS-T&RI course in casting design and stress analysis are **H. Kempe,** Belle City Malleable Iron Co., Racine, Wis.; instructor **Claude Smith,** Superior Steel & Malleable Casting Co., Benton Harbor, Mich.; **J. A. Lindgren,** M. H. Treadwell Co., New York; **H. R. Handlogten** and **Ed AuBuchon,** Sundstrom Aviation Co., Rockford, Ill.

New Casting Design Course Draws from U.S., Canada

Thirty-two foundrymen from 11 states and Canada attended the AFS-T&RI *Casting Design and Stress Analysis* course presented March 28-30 at the Bismarck Hotel, Chicago. The course, given for the first time, was held in response to industry requests.

Among the subjects covered were casting design and product development, advantages of castings as an engineering material, fundamentals of good casting design, use of stress analysis, economical design and production and modification considerations for lowest casting cost.

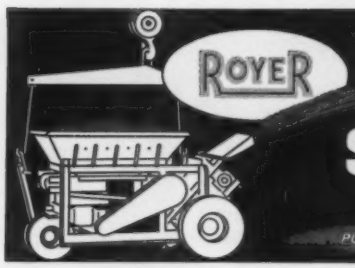
Foundrymen were warned that the future of the castings industry depends upon design, cost, quality and service. Casting design and product development must be incorporated into future plans of foundries.

Not only is there competition from other processes and changing needs of customers but there is the constant problem of maintaining a market for castings.

These include obsolescence of present applications, capturing of new markets, recapturing of applications already lost, the need for lower manufacturing costs, fitting of castings to fulfill the needs of ultimate service and design for better performance or cost.

Fundamentals of good casting design include: factors affecting placement of the parting line, gating and feeding requirements, core support and venting requirements, designing simplification, combining of several parts into one casting to reduce costs, when to drill rather than core holes, conversions to castings, punching holes and opportunities to reduce vehicle weights with higher strength ferrous castings.

Instructors were Jack Caine, consultant, Cincinnati; J. L. Flitz, Central Foundry Div., GMC, Saginaw, Mich.; G. W. Schuller, Caterpillar Tractor Co., Peoria, Ill.; Claude Smith, Superior Steel & Malleable Casting Co., Benton Harbor, Mich.; D. P. Miller, Falk Corp., Milwaukee; S. C. Massari, T&RI Director and R. E. Betterley, T&RI Training Supervisor.



SAND CONDITIONING TOPICS

PUBLISHED BY **ROYER**, MANUFACTURERS OF THE FOREMOST IN SAND CONDITIONING EQUIPMENT

ROYER OFFERS A PRACTICAL SOLUTION TO HOT SAND PROBLEMS

In today's foundry operation, time is probably the most costly element the superintendent must deal with. Sand used for today's casting must be conditioned and ready for use tomorrow. This frequently means sand conditioning at temperatures ranging up to 300° to 400°F.

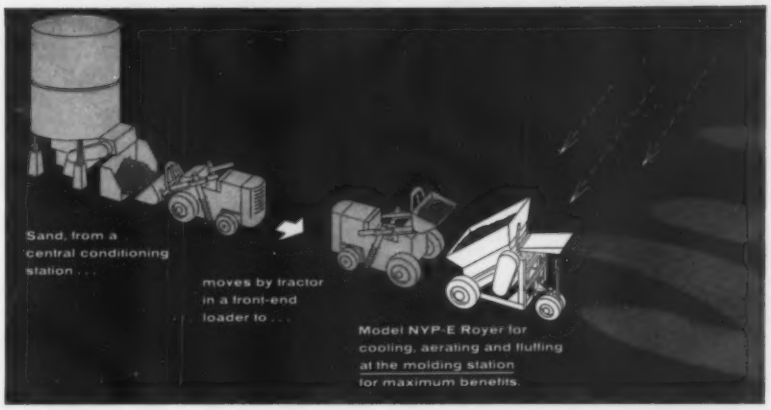
These destructive high temperature operating conditions seem to plague every foundryman. Foundry equipment suppliers have offered many possible solutions—cooling towers, shake-out belt cooling, water cooling, rotary cooling, bin cooling, etc. But probably no manufacturer has offered more thorough cooling per dollar of invested capital than that obtained with Royer equipment.

All Royer Foundry Units employ the famous Royer Belt Combing Principle. In operation, a combing and mixing action takes place in the feed hopper. This breakdown of the hot sand mass releases the hot gases as the first step



in Royer Cooling. Further cooling of the individual sand particles takes place as the conditioned sand is discharged in an open stream. And finally, the sand heap, now open, light and fluffy, continues cooling at a very rapid rate.

There is a Royer Foundry Unit to solve every sand conditioning problem. Your inquiry is invited. We promise prompt reply—without obligation.



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Here is a positive cost-cutting sand conditioning system that falls within the budget limitations of the small or medium semi-mechanized foundry. It delivers better sand without adding to time or manpower requirements, and without the expense of complete mechanization. It gains the advantages of fluffing after handling, as the final step at the molding station.



Teamed with front-end loader, this Royer NYP-E Portable moves from floor to floor in this grey iron foundry. What used to be caked, packed sand from mulling is now a cool, fluffy pile.

An integral part of this practical system is the Royer Model NYP-E Sand Separator and Blender. It can be moved swiftly from station to station, delivering cooled, aerated, fluffed, perfectly conditioned sand right where it's wanted. With this Royer you can really get all the advantages of central system sand control.

Your system is probably "different." There's still a versatile unit of the Royer "NY" Series to fit it . . . and improve it. As a stationary model, the "NY" will fit into a conveyor system, or can be installed to take the discharge of stiff sand directly from your muller. However you use it, the Royer vastly improves sand, saves time and money, improves yield and quality of castings —all at a fraction of a cent per ton of sand.

We'll be happy to have an experienced, foundry-wise Royer agent call to help you work out the system that's best for your operation. Or, if you prefer, we'll rush you a copy of Bulletin NY-54, giving further information about these units and how you will benefit from them. When you're convinced, *you* can call in your Royer agent and take the first step towards better sand with a Royer system.

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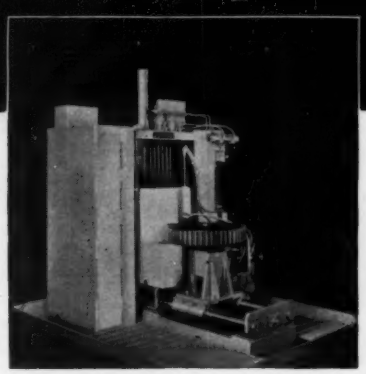
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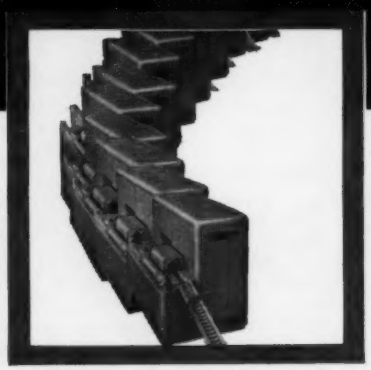
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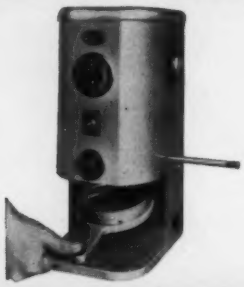
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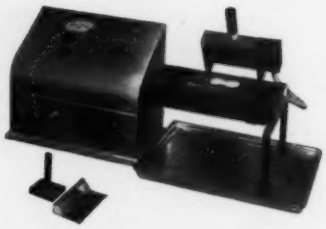
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chapter news

Western Michigan Chapter Sponsors Training Course for Instructors

A 14-week foundry instructors' course is now underway at Muskegon Mich., jointly sponsored by the AFS Western Michigan Chapter and the University of Michigan.

Three-hour classes are being held each Wednesday during the period March 9-June 8. Undergraduates or graduates will receive a credit of two hours upon payment of fees and submission of a comprehensive notebook to the University of Michigan. Foundry instructors from the area taking the course are enrolled free of charge where no course credit is desired.

The program includes a study of foundry tools and equipment, melting furnaces, sand control, melting practice, molding procedures, patterns, cleaning and finishing, progress evaluation and plant tours.

Instructors, all from the Western Michigan Chapter are: Joseph Cannon, Enterprise Brass Works Corp.; David Jacobson, Grand Haven Brass Co.; Adrian Archambault, Carpenter Bros., Inc.; Donald Hogan, Muskegon Public Schools; Cliff Lonnee, Alloyed Grairon Casting Co.; Elmer Carmody, Engineering Foundry Co.; Joseph Brooks, Muskegon Piston Ring Co. and Fritz De Hudy, Sealed Power Corp.

The initial meeting was an orientation kick-off banquet attended by 40 persons. Joseph Cannon planned the affair and briefly discussed the instructional materials to be furnished by the chapter. The program was conducted by Cliff Lonnee with comments made by Prof. L. H. Hodges, University of Michigan Extension Service; Edward Huttinga, Muskegon Schools; Charles H. Cousineau, Chapter Secretary; and Elmer Carmody, Chapter Chairman.

Ralph Betterley, AFS Educational Director, spoke on *AFS Educational Activities* and presented the Education Division's new film *Cast Metals and You.*

Said Betterley, "This is a most worthwhile and ambitious chapter educational project and it is hoped other chapters may be able to conduct similar programs." He further emphasized such a chapter program can provide valuable assistance to industrial art teachers who have had only limited foundry training experience on backgrounds.



Instructors and participants at the opening course of the 14-week program for foundry instructors sponsored by the **Western Michigan Chapter** and the University of Michigan.



Participating in initial meeting of the foundry instructors' seminar at Muskegon, Mich., are **Western Michigan Chapter** Chairman **E. J. Carmody, J. J. Cannon,** T&RI Training Supervisor **R. E. Betterley, Cliff Lonnee, Lewis H. Hodges,** Chapter Secretary **C. H. Cousineau** and **E. J. Huttenga.**



Attending the March meeting of the **Central Illinois** Chapter were: **J. R. Ellington,** U.S. Gypsum Co., **Ross Tarr** and **Eldon Whiteside,** U.S. Gypsum Co., and technical chairman **Ed Duncan,** Peoria Brass Foundry Co.



Proper use and care of molding machines was described at the March meeting of the **Northeastern Ohio** Chapter by **T. W. Harvey,** Grabler Mfg. Co., Cleveland. Harvey listed recommendations for an effective maintenance program. **—H. W. Wheeler**



Advantages and disadvantages of the CO_2 process were discussed at the March meeting of the **Northeastern Ohio** Chapter by **W. A. Mader,** Oberdorfer Foundries, Syracuse, N.Y., and Oswego Castings Co., Oswego, N.Y. Mader also described the potential of the process at the two foundries.—**H. W. Wheeler**



Four foundry experts formed a panel at the March meeting of the **New England** Chapter to discuss problems of melting costs, sands, cores and plant maintenance. Back row, left to right; Chapter President **Ahti Erkkinen**, Fremont Casting Co., Vice-President **Philip C. Smith**, General Electric Co. Front row: **Philip Gange**, General Electric Co., maintenance; **L. W. Greenslade**, Brown & Sharpe Mfg. Co., melting; **W. H. Ohlsen**, Draper Corp., sands. Not shown but participating was G. H. Ebelling, Whitin Machine Works, who spoke on core practice.

—F. S. Holway

Texas Chapter

Hears Foundry Mechanization Talk

■ Foundries often jeopardize investments in new equipment because they lack facilities to handle increased production, O. H. Kraft, Nomad Equipment Co., Milwaukee, told Texas foundrymen at their February meeting. Kraft emphasized the importance of having an overall plan when contemplating a modernization program. In an illustrated talk, he pointed out how molds and castings can be handled with pallets and rails in any type of foundry operation. Examples were shown ranging from simple manual installations to complete automatic operations, designed for use in foundries regardless of size.



Twin City Chapter

Conducts Joint Meeting

■ A joint meeting with the local chapter of the American Welding Society was held Feb. 8 with the American Hoist & Derrick Co. acting as hosts.

A plant tour was conducted with visits made to all parts of the foundry with various fabricating methods demonstrated including automatic welding of gears and numerous automatic machining processes. Also on the program was a dinner and a movie on hoist equipment used in bridge building. AFS Regional Vice-President H. M. Patton welcomed the nearly 300 members and guests. —*Matt Granlund*

Twin City Chapter

Use of Chemical Treatments

■ Chemical treatment of molten metals falls into four major classifications, R. W. Ruddle, Foundry Services, Inc., Cleveland, told foundrymen at the March meeting attended by 100 chapter members and guests.

These are reduction of melting losses, prevention of dross formation, removal of gases and promotion of grain formation. Three types of fluxes are used for aluminum-cover flux, drossing flux and special modifying fluxes. The precise treatment to be used depends upon several factors including alloy, fuel, form of charge, melting furnace and type of casting.

—*Matt Granlund*

Western New York Chapter

What's New in the Core Room?

■ Chemically-cured binder systems will be one of the major advances in the coreroom, Anton Dorfmueller, Archer-Daniels-Midland Co., told Western New York chapter foundrymen. First of the processes available for the 1960 market are the completely self-curing binders for large core work. These binders are similar to air-setting binders but upon removing the core from the box no further curing in a core oven is necessary.

New resins on the horizon for shell molding and shell core work will likely include these characteristics:

- Faster cure rate.
- Low curing temperatures.
- Lower resin consumption.
- Easier mulling.
- Better shakeout and less noxious fumes.
- Collapsibility for light metals.

—*Don Kreuder*

Central Illinois Chapter

Correction of Casting Defects

■ Aluminum casting defects and their correction were discussed at the March meeting by Donald LaVelle, American Smelting & Refining Co., South Plainfield, N. J.

Observations by LaVelle: porosity and inclusions are the principal defects . . . gas, shrinkage and entrapped air are three types of porosity . . . inclusions include oxides and dross . . . a simple test for gas is to freeze a sample in vacuum . . . degas by bubbling nitrogen or chlorine through bath . . . shrinkage reduced by a small amount of gas . . . trapped air bubbles cause 50 per cent of all trouble in aluminum castings . . . keep the sprue to the side of the mold . . . keep sprue full and use a rectangular sprue where possible.

A film, "Tooling and Patternmaking with Epoxical Resins" was shown by E. L. Whiteside, U. S. Gypsum Co., to the 150 members and guests attending the meeting. Chapter Chairman John Kauzlarich, Peoria Malleable Castings Co., presided with Ed Duncan, Peoria Brass Foundry Co., serving as technical chairman.

—*Charles H. Bavis*

Southern California Chapter

Why Casting Design?

■ A joint meeting was held in February with the local chapter of the Society of Non-Destructive Testing. J. B. Caine, consultant, Cincinnati, discussed casting design stressing the importance of design and its relation to maximum strength and minimum metal. More than 200 members of the two societies attended the meeting. E. G. Gaskell, Ace Foundry, Ltd., presided with C. F. Weisgerber, Alloy Steel & Metals Co., serving as technical chairman.

—*K. F. Sheckler*

Rochester Chapter

Safety in the Foundry

■ Hints on how to achieve safety in the foundry were presented in an illustrated lecture at the March meeting by George A. Riley, American Brake Shoe Co., New York. Among his recommendations: When an accident occurs, find the cause and prevent its repetition; make certain that electrical equipment is locked before working on machinery; make certain safety glasses are used; insist on safety shoes; don't let men wear rings.

Chapter Chairman Charles D. Loomis, General Railway Signal Co., Rochester, N.Y., presided at the meeting attended by 48 members.

—*Haerle Wesgate*

Northeastern Ohio--Die Casters Meet

Members of the **Northeastern Ohio Chapter** and 40 members of the Cleveland section, **Society of Die Casting Engineers** met in January. The joint meeting was coordinated by AFS Director Don Colwell. Photos by **Sterling Farmer**



Harry Cragin, Halex Die Casting Co., formerly chairman Cleveland S.D.C.E. and **Walter Bonsack,** Aluminum & Magnesium, Inc., one of the speakers.



David Morganstern, Nelmore Mfg. Co., former chairman of Cleveland section, S.D.C.E. and AFS National Director **Don Colwell,** Apex Smelting Co.



Walter E. Sicha, Aluminum Co. of America, past chairman of the Northeastern Ohio Chapter and AFS Director nominee and **Robert Black,** Rex Oil & Chemical Co., secretary of the Cleveland section, Society of Die Casting Engineers.



F. C. Bennett, Dow Chemical Co., Midland, Mich., Chairman of the AFS Die Casting & Permanent Mold Division and **James V. Christopher,** Tool-Die Engineering Co., Chairman, Cleveland section, Society of Die Casting Engineers.



Former **Mo-Kan Chapter** Chairmen, back row: **H. P. Schwickrath, J. T. Westwood** and **Lloyd Canfield.** Front row: **Les Neville** and **Tom Shadwick.** Past chairmen were presented with certificates of appreciation. Brief talks were made to the chapter by AFS Secretary A. B. Sinnett and Regional Vice-President Webb L. Kammerer.

University of Illinois Student Chapter





Northeastern Ohio Chapter Chairman **A. H. Hinton,** Aluminum Co. of America and **Richard C. Meloy,** Gray Iron Founders' Society, Cleveland, hold chat prior to Meloy's discussion of profitable foundry marketing at the chapter's February meeting. The speaker discussed varied forms of organized selling adopted by foundries. **—Harold Wheeler**



Modern management practices leading to profitable foundry operations was discussed at the February meeting of the **Northeastern Ohio** Chapter by **Harry E. Figgie, Jr.,** Booz, Allen & Hamilton, Cleveland, shown on left. **A. D. Barczak,** Superior Foundry, Inc., Cleveland, served as technical chairman.



Problems associated with the loss of hearing and workmen's compensation were outlined at the **Northeastern Ohio** Chapter February meeting by **H. J. Weber,** AFS Director of Safety, Hygiene and Air Pollution Control Program, left. **E. E. Harkess,** Ford Motor Co., Cleveland, served as technical chairman.

—Harold Wheeler

Western New York Chapter

Hears Ductile Iron Talk

■ Ductile iron can be produced to proper specifications only when the foundry makes the necessary effort to control the operation, Charles Green, Sorbo-Mat Process Engineers, told chapter members in March. Green pointed out that unless this control is achieved, high quality ductile iron cannot be achieved.

—Don Kreuder



University of **Alabama Student Chapter** members conducting demonstration for visiting members of the AFS **Birmingham Chapter.**



Past Chairmen of the **Metropolitan Chapter** were honored at the March meeting with the presentation of aluminum ash trays made by students. Standing are **J. S. Vanick, B. N. Ames, J. A. Bukowski, T. J. Wood, H. L. Ullrich** and **D. S. Yeomans.** Seated: Chapter Chairman **R. B. Fischer** and past chairmen **W. E. Day, Jr., D. J. Reese, J. W. Reid.** —J. P. O'Neill



Use of plastics in patternmaking was outlined at the March meeting of the **Philadelphia Chapter** by **R. L. Rouviere,** Devcon Corp., Danvers, Mass. He suggested high quality wood for the original pattern but plastics for duplicate patterns due to economy, sharpness of detail and less shrinkage. Shown are Technical Chairman **Donald Volk,** Alloy Steel Casting Co., speaker Rouviere and Chapter Chairman **E. A. Zeeb,** Dodge Steel Co.
—Leo Houser, E. C. Klank



Philadelphia Chapter members from Palmyra Foundry Co., Palmyra, N.J., attended the March meeting dealing with the use of plastics in patternmaking. Group was headed by President **Arthur A. Thum** (left). Also attending were **George R. McClelland, Harry J. Timmons, Lester Mount** and **Anthony J. Derrick.**
—Leo Houser, E. C. Klank

Alabama Student Chapter

Meets with Birmingham Chapter

■ Members of the Birmingham Chapter and the University of Alabama Student Chapter met in March at the university with the entire program handled by the Student Chapter in cooperation with the metallurgical department of the university.

Demonstrations on the fluidity of metal, effect of pouring temperature on physical properties of metal, the effect of gas content on a metal and degassing of the metal and a demonstration of the plunging technique for the production of nodular iron were conducted by foundry students.

Fifteen Foundry Educational Foundation scholarships were presented by E. C. Wright, head of the metallurgical engineering department.

One hundred students and foundrymen attended the meeting with Student Chapter Chairman T. T. Bales presiding. —*John A. Jetton*

Western Michigan Chapter

Shell Molds and Cores

■ Over 130 chapter members and guests attended the March meeting in Grand Rapids, Mich., to hear John Albanese, Acme Resin Corp., discuss shell molds and cores. A special welcome was held for 22 new members. —*John R. McNamara*

Detroit Chapter

Use of Moldable Exothermics

■ Production and use of moldable exothermics and their growing use in the casting industry were explained at the March meeting by R. W. Ruddle, Foundry Services, Inc. Ruddle emphasized that their use is increasing, particularly in the non-ferrous field.

Winners were announced in the chapter's apprentice contest. The first three places in wood patternmaking went to Adam Kravetz, Progress Pattern Co., Alan Larson, K & W Pattern Co., and Gordon Gotberg, Automotive Pattern Co. Winners in metal patternmaking were James Arnold, Progress Pattern Co., Dave Brine, Peerless Pattern Co., and John Burmeister, Washtenaw Pattern Co. The contest was sponsored by the Education Committee headed by R. Gardner with M. D. Markarian serving as contest chairman.

Judges were Richard Broniman, Majeske School; Fred Londel, Automotive Pattern Co., Ralph Schowalter, Dodge Foundry Co., Ray Duquette, Washtenaw Pattern Co., Charles Haug, Peerless Pattern Co., and Robert Spengler, Annex Pattern Co.
—*J R. Young*



AFS Regional Vice-President **H. M. Patton,** American Hoist & Derrick Co., St. Paul, Minn., addresses joint meeting of **Twin City Chapter** and the local chapter of American Welding Society. Seated are key personnel of American Hoist & Derrick Co. **—Matt Granlund**



Most distant AFS member in the **Philadelphia Chapter** is Frogswitch Mfg. Co., Carlisle, Pa., 120 miles away. Three members attending the March meeting were **Gene Fisher, J. C. Feeser** and **Peter Scully. —Leo Houser, E. C. Klank**



Ductile iron was discussed at the March meeting of the **Western New York** Chapter by **Charles Green,** Sorbo-Mat Process Engineers. Shown are speaker **Green,** Chapter Chairman **Ed. O'Connell,** American Standard Radiator Co. and Educational Chairman **Walt Steiner,** Worthington Corp. **—Don Kreuder**



Frank Ryan, St. Paul Brass Foundry Co., St. Paul, Minn., chairman of the **Twin City** educational committee, explains foundry display showing the development of a casting from sand and pattern to finished product. The display is shown to vocational classes in the Twin City area. **—Matt Granlund**



Application of induction melting to foundry requirements was explained at the February meeting by H. M. Rowan, Inductotherm Corp. Shown are Chapter Chairman **Don Caudron,** Pacific Brass Foundry of San Francisco; speaker **Rowan;** Vice-Chairman **Hugh Prior,** Superior Electrocast Foundry. **—E. J. Ritelli**



Participating in the March meeting of the **Western New York** Chapter were Chapter Secretary **Ron Turner,** Queen City Sand & Supply Co.; **Bruce Artz,** Pangborn Corp.; Chapter Chairman **Ed. O'Connell,** American Standard Radiator Co.; and **Jules Hubble,** Chevrolet-Tonawanda Div., GMC.



J. E. Campbell, McKinnon Industries, warned foundrymen at the February meeting of the **Ontario Chapter** that "haywire" and "fire brigade" methods of preventive maintenance may stand between profit and loss. **—Vincent Furlong**



Texas Chapter Vice-Chairman **E. A. Schlotzhauer,** Federated Metals Div., American Smelting & Refining Co.; Chairman **Ross Williams,** East Texas Steel Castings Co.; and **O. H. Kraft,** Nomad Equipment Co., the speaker. **—O. H. Kraft**



Attending the March meeting of the **Mo-Kan Chapter** were AFS Secretary **A. B. Sinnett** and Regional Vice-President **Webb L. Kammerer,** Midvale Mining & Mfg. Co., St. Louis, and Chapter Chairman **C. H. Ossenfort,** Fairbanks, Morse & Co. **—John Marshall**



Chemical treatment of molten metals was explained at the March meeting of the **Twin City Chapter** by R. W. Ruddle, Foundry Services, Inc., Cleveland. Shown are speaker **Ruddle** and **Harry Blumenthal,** American Iron & Supply Co., technical chairman.

British Columbia Chapter

Panel on Costing a Casting

■ A panel discussion on costing a casting in iron, steel, aluminum and brass was conducted at the February meeting. Herb Heaton, Mainland Foundry Co., Vancouver, B.C., served as moderator. Panelists were Lovick Young, A-1 Steel & Iron Foundry Co.; Ray Nye, Nye's Foundry, Ltd.; Frank Busst, Acme Aluminum Foundry Ltd.; John Hopkinson, North Shore Foundry Co.

Each speaker outlined how they would cost a representative casting giving estimates of time as well as recommendations for gating and risering *—J. B. Hopkinson*



First place winners in the **Detroit Chapter** contest were won by apprentices from Progress Pattern Co. **James Arnold**, left, was first in the metal patternmaking and **Adam Kravetz**, center, was first in wood patternmaking. On right is **William Shaw**, owner of Progress Pattern Co.
—J. R. Young



Chicago Chapter Education Chairman **John Harwood** congratulates **Edward McFaul** who spoke at the opening session of the chapter's series on the theme "Supervision—Key to Foundry Progress." —George DiSylvestro



Detroit Chapter's apprentice contest, sponsored by the education committee, was headed by **Robert Gardner**, Ford Motor Co., right. **Ray Duquette**, Washtenaw Pattern Co., was a judge in the metal patternmaking competition.



W. D. Dunn, AFS Regional Vice-President and former **Central New York Chapter** Chairman, left, presents plaque to **Ralph Denton** signifying his acceptance into the chapter's past chairmen's club. —Lewis Balduzzi



Attending the **Chicago Chapter's** educational series were **Leo Marinelli**, Kensington Steel Co. and **Tito Tarquino**, American Brake Shoe Co., Chicago Heights, Ill.—George DiSylvestro



Speakers at the second session of the **Chicago Chapter's** three meeting educational series on supervision as the key to foundry progress were **A. J. Bohl**, Wolf Management Engineering Co., Chicago, left, of Chapter Education Chairman **J. C. Harwood**, and **I. G. Robinson**, Lester B. Knight & Associates, Chicago. —George DiSylvestro



Cast to size patterns, die blocks and permanent molds were discussed at the March meeting of the **Saginaw Chapter** by **W. R. Weaver**, Modern Pattern & Plastics, Inc., Toledo, Ohio. Nearly 200 foundrymen attended.
—John R. Fraker

Attendance Stimulators

■ Two additional chapters report success with attendance stimulators. The Wisconsin Chapter uses a system of five "treasure chests." One includes a ticket for a portable radio; the other four chests include AFS jewelry. Five names are picked from the ticket stubs for the evening. The first picked has choice of the five boxes.

The Twin City Chapter has a similar plan, using a gift as a door prize. This is available to members only and is not drawn until after the speaker has completed his talk.

Ontario Chapter

Preventive Maintenance Talk

■ Continuous uninterrupted production, not for just one day, but for extended periods accomplished on a minimum maintenance budget should be the goal of management and its maintenance program, said J. E. Campbell, McKinnon Industries, St. Catharines, Ontario, at the February meeting.

Campbell recommended a carefully organized, systematic inspection and lubrication program of all machines and equipment with a follow-up program of planned work schedules for major repairs and immediate correction of minor items. He emphasized that such a program must be developed by each plant.

Foundrymen were warned that use of the "haywire" and "fire brigade" systems could well make the difference between a profit and loss in today's competitive market.

—Vincent Furlong

Chesapeake Chapter

Constructing Wooden Patterns

■ In building a wooden pattern for dimensional stability over a long period of time and to keep it as free as possible from repair, it is not a question of building it with a maximum of lumber. "The more lumber used, the greater the chance of warpage. And increased weight could make it more likely to be damaged in handling," said Walbert Siebert, Cleveland Standard Pattern Works, Cleveland, at the February meeting.

The answer lies in engineered construction. For instance, the construction of heads for the pattern backbone—make it simple. Two layers of 2-in. pine of good grade, perhaps 6 in. wide and spaced no more than 18 in. apart, should be tied together with stringers measuring about 2x5 in. Screw directly to the heads—don't notch into them.

On the inside of the heads, attach two stringers, 8-10 in. wide, directly to the bottom in an upright position to strengthen the cope side of the pattern. Staves or lagging of no less than 1-1/4 in. stock in pine or 1-1/2 in. mahogany, should run in the direction of the draw and be no wider than 6 in. with a 1/32-in. space between each board. *—V. R. Chastang*

Eastern Canada Chapter

Metal Penetration Problems

■ Problems of metal penetration were discussed at the March meeting by Sol Gertsman, Physical Metallurgy Div., Department of Mines & Technical Surveys, Ottawa, Ont. Gertsman said that opportunities for penetration were reduced with the closer packing of sand grains. Slides were shown on different types of penetration due to gassed metal, especially with phosphor bronze alloys.

—Jim Cherrett

St. Louis Chapter

Hears Talk on Scrap Reduction

■ Ways and means of reducing scrap and how to train foremen to participate in the program were explained at the February meeting by K. M. Smith, foundry consultant. E. E. Hart, East St. Louis Castings Co., served as technical chairman with R. E. Hard, St. Louis Coke & Foundry Supply Co., chapter chairman, presiding.

—W. E. Fecht.

St. Louis Chapter

Reducing Blast Cleaning Costs

■ One-hundred chapter members and apprentices at the March meeting heard Don Swardson, Wheelabrator Corp., discuss methods of reducing blast cleaning costs. Apprentice winners in the chapter's contest were also announced. They are:

Wood Patternmaking—D. Kuenzel, Central Pattern Co.; G. Wood, Arnette Pattern Co.; W. Cunningham, Consolidated Pattern & Mfg. Co.

Metal Patternmaking—R. Heckel, Progressive Pattern Co.; P. Niebur, Central Pattern Co.; T. Bafwall, Progressive Pattern Co.

—W. E. Fecht

Ontario Chapter

Conducts Panel Discussion

■ Local markets are favored by casting purchasers who are concerned primarily with prices and delivery dates, quality of castings being a foregone conclusion. Suggestions to foundrymen in making bids from the purchasing panel at the March meeting:

- Get all of the details from your customer.
- If there is anything missing, ask for it.
- If there are suggestions for alterations of alloy or design, inform your customer immediately.
- Keep delivery dates.
- Ensure good relationships between your salesman and customer.

Panel members were: J. A. Hishon, Canadian Westinghouse Co., Ltd., and P. C. Grinter, Worthing Canada (1955) Ltd., representing purchasing; F. Jobson, Canada Iron Foundries, Ltd., chief estimator. G. Phelps, Otaco Foundry Ltd., served as technical chairman. *—Vincent H. Furlong*

Central New York Chapter

Copper Alloy Chemical Treatment

■ Substantial reductions in melting losses can often be produced by the uses of fluxes, R. W. Ruddle, Foundry Services, Inc., told foundrymen at the March meeting. Ruddle also discussed the use of fluxes for the removal of certain elements such as iron, zinc, phosphorous, arsenic, lead and silicon.

Ruddle also spoke on degassing—dealing first with gas flushing methods. The mechanism of these methods was covered in a general way and the speaker then described their application to copper and aluminum alloys, comparing and contrasting the various types of gas scavenging degassers available. He pointed out that these could be divided into two groups: 1) Materials such as nitrogen and chlorine which are piped into the melt and 2) materials such as chlorinated hydrocarbons which are plunged in solid form to the bottom of the melt generating the gaseous flux.



R. W. Ruddle

Chemical means of controlling the grain size of light alloys was also covered. The grain size of the casting depends upon the number of nuclei present in the melt which can serve as centers of crystallization. If this number is large, the grain structure is fine. The problem of producing a fine grain size in the casting is one of generating a sufficient number of nuclei in the liquid prior to solidification. Additions of titanium and boron either singly or in combination are often used for this purpose. Additions of titanium alone have some objection in that nuclei produced tend to disappear if the melt temperature is raised much above 1300 F. The addition of boron alone tends to be objectionable since this element is inclined to give rise to mold reaction during solidification and cause gas absorption. *—Lewis Balduzzi*

afs chapter meetings

MAY

Birmingham District . . May 20 . . Thomas Jefferson Hotel, Birmingham, Ala. . . *Panel on Modern Molding & Core Methods.*

British Columbia . . May 20 . . Leon's, Vancouver, B. C.

Central Illinois . . May 2 . . Vonachen's Junction, Peoria, Ill. . . C. E. Westover, Westover Corp., *"Mechanization for Small Foundries."*

Central Indiana . . May 2 . . Athenaeum, Indianapolis . . *Past Chairmen's Night.*

Central Ohio . . May 1 . . Shawnee Hotel, Springfield, Ohio . . *Round Table Discussion—Gray Iron*: J. E. Haller, James B. Clow & Sons; *Malleable*: R. F. Reetz, Dayton Malleable Iron Co.; *Steel*: G. B. Greenwood, Buckeye Steel Castings Co.; *Non-Ferrous*: P. Ritzer, Franklin Brass Foundry.

Chesapeake . . May 27 . . Engineers' Club, Baltimore, Md. . . M. Bock, Exomet, Inc., *"Gating & Risering."*

Chicago . . May 2 . . Chicago Bar Association, Chicago . . J. R. Irish, Texas Foundries, Inc., *"Short Cuts—Texas Way."*

Corn Belt . . May 21 . . Beatrice Country Club, Beatrice, Neb. . . *Annual Stag Party.*

Detroit . . May 5 . . Wolverine Hotel, Detroit . . W. H. Dawson, International Nickel Co., Inc., *"Ductile Iron, Today & Tomorrow."*

Eastern Canada . . May 27 . . Mt. Royal Hotel, Montreal, Que. . . *Presentation of Winning Entries, Paper Writing Competition.*

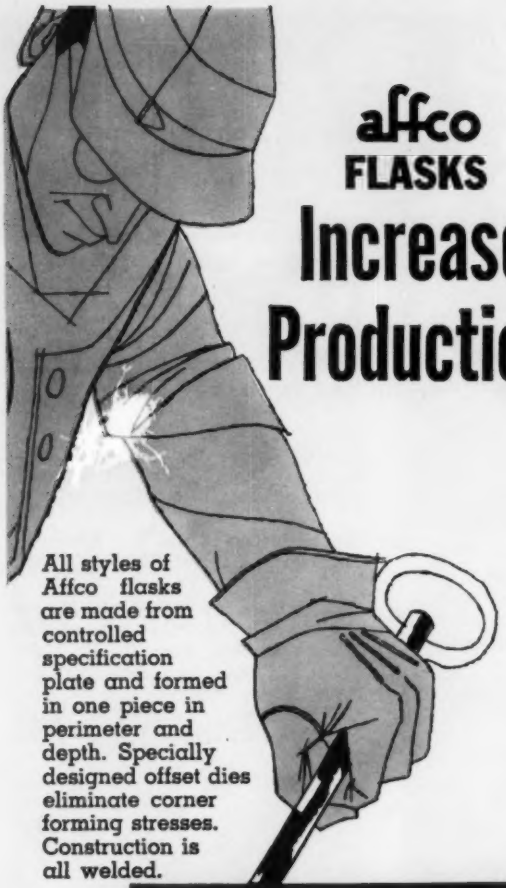
Mexico . . May 23 . . Chapultepec 412, Mexico City, Mexico . . F. G. Vargas, University of Mexico and Instituto Politecnico, *"Possible Application of Metallurgical Blast Furnace & Oxygen Converter for Production of Castings in Mexico."*

Mid-South . . May 13 . . Hotel Claridge, Memphis, Tenn. . . L. S. Wilcoxson, International Nickel Co., *"Gray Iron Metallurgy."*

Mo-Kan . . May 19 . . Fairfax Airport, Kansas City, Kans. . . *Election of Officers.*

Northeastern Ohio . . May 19 . . Tudor Arms Hotel, Cleveland . . *Recognition*

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Circle No. 162, Page 207

Night—Apprentices, Old Timers, AFS National Officers and Past Chairmen.

Northern California . . May 16 . . *Plant Visitation.*

Ontario . . May 27 . . Royal Connaught Hotel, Hamilton, Ont. . . C. A. Sanders, American Colloid Co., *"Comparison of Molding Methods."*

Pittsburgh . . May 16 . . Webster Hall Hotel, Pittsburgh, Pa. . . R. Farwell, Pennsylvania State University, *"Development of Personnel."*

Quad City . . May 16 . . LeClair Hotel, Moline, Ill. . . C. A. Koerner, Central Foundry Div., GMC, *"New Foundry Testing Methods."*

Saginaw Valley . . May 5 . . Fischer's Hotel, Frankenmuth, Mich. . . O. L. Crissey, General Motors Institute, *"Effective Human Relations in the Foundry."*

Texas, San Antonio Section . . May 23 . . Alamo Iron Works, San Antonio, Texas . . *Election of Officers.*

Tri-State . . May 6 . . Alvin Hotel, Tulsa, Okla. . . W. Siebert, Cleveland Standard Pattern Works, *"Patterns & Construction."*

Twin City . . May 10 . . Jax Restaurant, Minneapolis . . D. E. Balzano, Ben Sadoff Iron & Metal Co., *"Scrap Is a Raw Material."*

Washington . . May 19 . . Tacoma, Wash. . . *Plant Visitation, American Smelting & Refining Co.*

Western Michigan . . May 2 . . Bill Stern's, Muskegon, Mich. . . C. O. Schopp, Link Belt Co. Ewart Plant, *"Foundry Flexibility."*

Western New York . . May 5 . . Sheraton Hotel, Buffalo, N. Y. . . *Annual Smorgasbord Meeting.*

Wisconsin . . May 6 . . Schroeder Hotel, Milwaukee . . C. A. Sanders, American Colloid Co., *"There's a Little Dutch in the Sand."*

* Many Chapters have canceled May meetings to avoid conflict with AFS Annual Castings Congress and Exposition.

JUNE

Central Illinois . . June 11 . . 497th Engineers Club House, Groveland, Ill. . . *Annual Clambake & Barbecue Stag.*

Central New York . . June 18 . . Hinerwadel's Grove, North Syracuse, N. Y. . . *Clam Bake.*

Chesapeake . . June 11 . . Bowley's Quarters . . *Crab Feast.*

Cincinnati District . . June 13 . . Elks Country Club, Hamilton, Ohio . . *Annual Summer Outing.*

Connecticut . . June 17 . . Restland Farms, Northford, Conn. . . *Outing.*

Detroit . . June 25 . . Detroit, Mich. . . *Outing.*

Northeastern Ohio . . June 25 . . Brookside Country Club, Barberton, Ohio.

Northern Illinois & Southern Wisconsin . . June 4 . . Morse Hills Country Club, Beloit, Wis. . . *Picnic.*

Pittsburgh . . June 6 . . Churchill Valley Country Club, Churchill, Pa. . . *Annual Picnic.*

Saginaw Valley . . June 4 . . IMA Lodge, Potters Lake . . *Annual Outing.*

Washington . . June 11 . . Birch Bay, Wash. . . *Inter-Chapter Golf Tournament with British Columbia Chapter.*

Western New York . . June 18 . . Sturm's Grove, Buffalo, N. Y. . . *Annual Stag Outing.*

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The chemical composition is the same. The work hardened hardness is the same—from 450 to 650 Bhn. But new *pre-hardened* Rol-Man steel can be *furnished* with an initial Bhn of from 250 to 400—as compared with from 180 to 215 Bhn for the standard Rol-Man steel.

You get the picture. *Pre-hardened* Rol-Man steel is no longer so soft and ductile . . . no longer unbreakable. But its new hardness gives it a head start—and because it is hard all the way through, it stays ahead. Yet it still develops the full potential work hardness of the standard Rol-Man steel.

Pre-hardened Rol-Man steel has done an outstanding job for a large auto maker in one application. (Guide rails on a molding machine.) But we'd like to show you what it can do in hopper liners, charging bells, tumbling barrels and shot blast equipment. Just send us a drawing of the part you're interested in and we'll submit a quotation.

One note of caution. Don't order raw stock of this new *pre-hardened* Rol-Man steel. The standard is tough enough to work, the pre-hardened is *impossible*. Heck, after it is pre-hardened, you can't even *weld* it.

One other caution. The new *pre-hardened* Rol-Man steel may not be the best for every job. There's nothing wrong with the standard Rol-Man steel. There are applications for both varieties.

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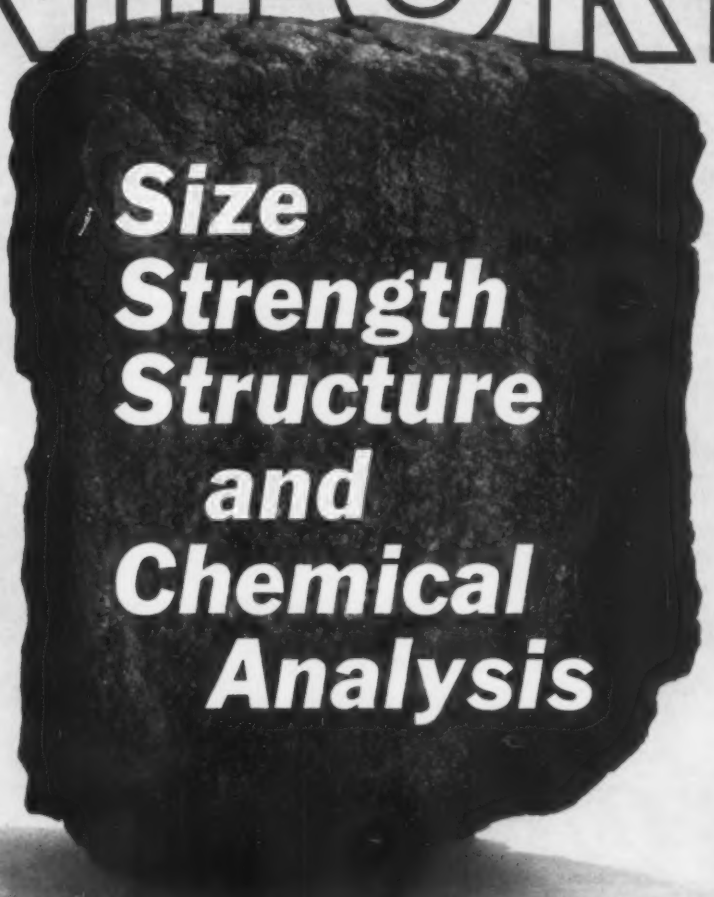
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Circle No. 164, Page 207

products and processes

For other new products and processes see the Exhibitors Product Review on page 71.

PREALLOYED FURNACE CHARGES . . . reportedly cut melting time due to high density and uniform analysis. Charges are adaptable to any type or size furnace used in melting high temperature alloys. Available as briquets or sheared solids. Security Alloys Co.
For More Information, Circle No. 2, Page 207

LOW-CARBON FERROCHROME . . . with rapid solubility adds speed in stainless steel melting. In one test 3300 lb of the alloy dissolved in a 15-ton heat after refurnacing dissolved before ladle was half full. Union Carbide Corp.
For More Information, Circle No. 3, Page 207

ONE-PIECE RAPPER . . for electrostatic precipitators and dust collectors are said to eliminate 80 per cent of maintenance problems. Rappers have no assembly bolts to stretch or shear or separate from striking plate to leak air from housing. Can be arranged with a solenoid valve and timer for complete automatic control. National Air Vibrator.
For More Information, Circle No. 4, Page 207

FLOOR-TYPE RAMMERS . . . have specially-designed front seal preventing entrance of sand or abrasive material into bore or guide of barrel. Packing unit is self-adjusting to compensate for wear and thereby keep power and speed at a maximum. Advantages claimed: consistently uniform blow that increases mold hardness faster; twice as many blows per min with same amount of air consumption; better quality mold with less ramming at increased speeds. Ingersoll-Rand Co.
For More Information, Circle No. 5, Page 207

NON-FERROUS METAL CLEANER . . . removes stains and at same time protects against discoloration and corrosion through silicate-buffered system that deposits molecular film on surface. S. C. Johnson & Son, Inc.
For More Information, Circle No. 6, Page 207

PORTABLE MOLD DRYER . . . gas-fired, designed for use on pit molds and flask molds too large for ovens. Foundry Equipment Co.
For More Information, Circle No. 7, Page 207

SEMI-AUTOMATIC SHELL CORE BLOWER . . . has maximum box size of 10x12x15 in., maximum core weight, before draining, of 20 lb and sand feed hopper capacity of 250 lb. Master control lever shuttles box under blow head, clamps it, blows, unclamps and shuttles box to rollover drain position. Sand fed automatically from feed hopper into blow magazine. Hopper can be replenished without stopping production. Demmler Mfg. Co.
For More Information, Circle No. 8, Page 207

INDUSTRIAL LIFT TRUCK . . . gasoline or LP-gas powered, comes in capacities of 3000, 4000 and 5000 lb. Features interlocking I-beam mast construction, cushion tires and short turning radius. Yale & Towne Mfg. Co.
For More Information, Circle No. 9, Page 207

AIR-POWERED BAIL-TYPE SHAKEOUT . . . reportedly empties large flasks quickly with minimum damage. Long-stroke piston, heavy-duty unit operates at 80 psi producing 1440 vibrations per min. Vibration frequency and intensity regulated by changing air pressure. Cleveland Vibrator Co.
For More Information, Circle No. 10, Page 207

SAND BLASTING GUN . . . for portable unit features pistol-grip allowing fingertip control and twice the blasting power of previous models. New design permits use of most sand blasting abrasives and features three different nozzles. ALCO Co.
For More Information, Circle No. 11, Page 207

EXPENDABLE IMMERSION THERMOCOUPLE . . . designed for use in open hearth or electric furnaces has a

Continued on page 184



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STANDARD QUALITY

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Circle No. 166, Page 207



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Circle No. 167, Page 207

Products and Processes

Continued from page 182

ceramic base which serves as a mounting for the noble metal thermocouple wires. A firmly anchored transparent fused silica tube protects thermocouple wires. Tube is protected from slag and floating solids by a special metal cap. Cap absorbs the physical shock of immersion and melts away immediately after it has plunged beneath the slag. Englehard Industries, Inc.

For More Information, Circle No. 12, Page 207

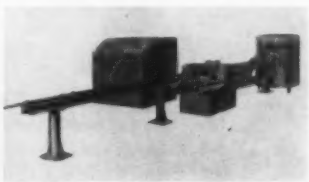
DISK GRINDING VISIBILITY . . . greatly increased by special abrasive disk with two parallel straight sides. As the disk rotates, a full inch at its outer edge becomes semi-transparent as shown in photo. Advantages claimed include faster grinding since disk need



not be moved for inspection, dwell time reduced because grinding can be confined to area that requires it and contour work and blending of welds becomes possible since the grinding is intermittent. Burning and heat distortion are minimized. Available in 7 and 9-in. sizes. Behr-Manning Co., Div. Norton Co.

For More Information, Circle No. 13, Page 207

AUTOMATIC-HORIZONTAL-CONTINUOUS-CASTING . . . machine produces cast iron and bronze bars of any length in diameters from 3/4 to 4 in. Process uses water-cooled mold giving greater chilling effect than sand mold. Metal develops excellent mechanical properties such as high tensile strength and elongation, lower hardness and a dense structure. Machine has a metallic yield of nearly 100 per cent, gives a clear surface free from sand inclusions



and a small machining allowance for fully machined bars. Polytechnica Winterthur.

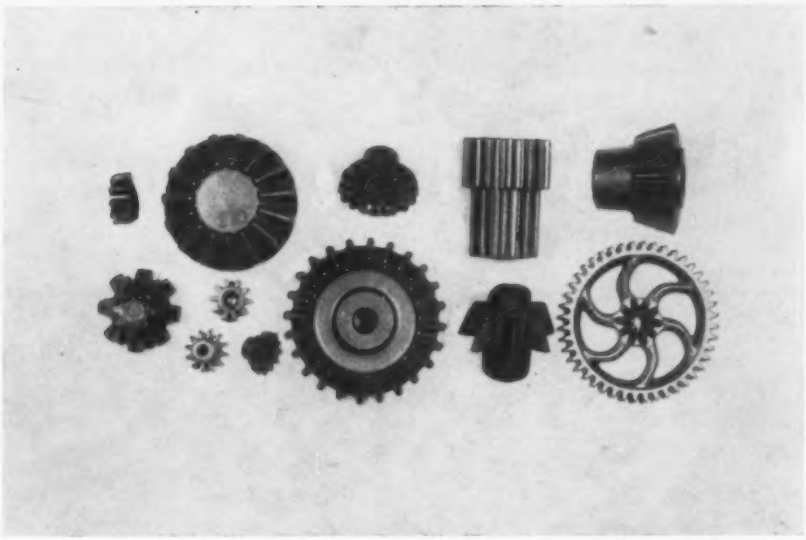
For More Information, Circle No. 14, Page 207

VOLCLAY BENTONITE

..... NEWSLETTER No. 67 .....

REPORTING NEWS AND DEVELOPMENTS IN THE FOUNDRY USE OF BENTONITE

Proof That It Can Be Done



Castings and photo compliments of P. R. Rentschler and
R. R. Deas, Jr., Hamilton Foundry Inc., Hamilton, Ohio

The castings in the above photo vary from ½" to 6" in length, width or diameter size. Most are between ⅛" to 1" section size. Weights vary between .48 oz. to 2½ lbs. **Larger castings are being produced** with similar casting finishes but tolerances are not held as closely.

Hamilton Foundry Inc. is one of many good foundries producing close dimensional tolerance castings with green sand molding.

Close tolerance is claimed by other practices but equal dimensional accuracy is presently being achieved **in green sand** by some foundries, along with excellent casting finish.

Green sand castings can be made to pattern size, equal to other methods, but it requires "know how" with a proper sand mixture.

For those interested in producing closer tolerances, improved casting finish and better dimensional controls, write for full information on GREEN SHELL CARB mixtures. **This is one mixture that can get the job done!**

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SKOKIE, ILLINOIS • PRODUCERS OF VOLCLAY AND PANTHER CREEK BENTONITE

Circle No. 168, Page 207

foundry trade news



Past and present officers and trustees of the Foundry Educational Foundation college and industry conference held March 16-17 in Cleveland. The group discussed modern ways of teaching new foundry technology.

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FOUNDRY EDUCATIONAL FOUNDATION . . . The relationship of the engineering sciences to the casting processes served as the basic theme for the 13th Annual College-Industry Conference of the Foundry Educational Foundation, March 16-17, Cleveland. Over 100 foundry industry men and 37 educators learned about the new foundry technology and modern ways of teaching it.

The conference was opened with remarks by F.E.F. President Frank G. Steinbach, followed by reports of the officers and the election of trustees.

Eight professors from colleges with F.E.F. programs presented the following talks:

Mechanics of Solids, Prof. Merton Flemings, Massachusetts Institute of Technology.

Mechanics of Fluids, Prof. J. F. Wallace, Case Institute of Technology.

Transfer and Rate Processes, Prof. R. A. Flinn, University of Michigan.

Thermodynamics, Prof. R. W. Heine, University of Wisconsin.

Electrical Sciences, Prof. M. S. Burton, Cornell University.

Nature and Properties of Materials, Prof. R. E. Swift, University of Kentucky.

Engineering Analysis and Design, Prof. B. W. Niebel, Pennsylvania State University.

Production Engineering, Prof. E. P DeGarmo, University of California

Special luncheon speakers were: Dean Curtis L. Wilson, Missouri School of Mines & Metallurgy, on the topic, *Engineering Education in Transition,* and Elmer E. Braun, works manager, Central Foundry Div., GMC, with the subject, *A Full House.*

Officers for the current year are: president—R. B. Parker, American Brake Shoe Co.; vice-president—D. H. Morgan, Dow Chemical Co.; secretary—Anton Dorfmueller, Jr., Archer-Daniels-Midland Co.; treasurer—E. M. Knapp, Ferro Machine & Foundry, Inc.; executive director—E. J. Walsh, Foundry Educational Foundation; and immediate past-president—F. G. Steinebach, Penton Publishing Co.

Steel Founders' Society . . . stressed future plans for the society at its annual meeting held March 7-8 in Chicago. Incoming president W. H. Moriarty, National Malleable & Steel Castings Co., Cleveland, assumed the presidency at the conclusion of the meeting. He advocated a more intensive marketing program including making use of market research data, product promotion and creative selling in expanding and creating new markets for steel castings in the 60s. A panel composed of Moriarty and past-presidents recommended that consideration be given to new statistical methods to assure maximum capacities and check efficiencies of steel foundries, participation by management in research activities, investing of a greater share of the sales dollar in research and the use of information provided by the society's

An announcement
of importance to foundrymen
seeking improved
cupola operations

Higher yields of strong, dense, consistently more machinable castings are possible through the use of *new* Ferrocarbo® Briquettes...the only cupola deoxidizer containing an expanding agent, catalyst and a slag activator.

The unique expanding agent causes disintegration of the briquettes and assures maximum distribution of their active ingredients at temperatures which provide optimum reaction with the molten metal and slag.

The addition of a catalyst to the briquette promotes faster and more complete reaction of the briquette's active ingredients.

The slag activator lowers the viscosity of the slag which assures rapid and uniform distribution of the briquette throughout the slag, and promotes the absorption of the sulfur from the iron.

Ferrocarbo Distributors—Kerchner, Marshall & Company, Pittsburgh • Cleveland • Buffalo • Detroit • Philadelphia Birmingham • Los Angeles • Canada
Miller and Company, Chicago • St. Louis • Cincinnati

new **FERRO CARBO** *briquettes*

by **CARBORUNDUM®**

see you at the
Foundry Show,
in Philadelphia,
May 9-13,
Booth 1110.

H 64-00

Circle No. 170, Page 207

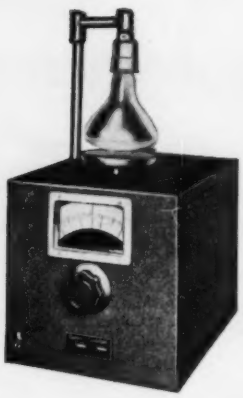
NOW

Sand Control

BY

TABOR

TRADE 1884 MARK



Moisture Tester



Utility Mixer



Permtester



Standard Testing Sieves

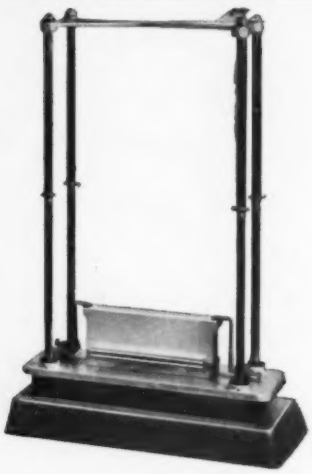


Core Hardness Tester

Combination Rammer-Compression Tester



Sand Washer



Transverse Test Core Maker

Tabor Manufacturing Company, long dedicated to cutting foundry costs, proudly offers a complete line of sand control equipment. The equipment simplifies sand control procedures, while maintaining rigid control. Equipment designs are based on the recommendations of the Committee on Foundry Sand Research of the American Foundrymen's Association.

Tell your Tabor Representative about your sand control problems. He'll show you where procedures can be simplified to help you save time, reduce scrap, and improve production and quality of castings.

TABOR MANUFACTURING COMPANY

Division of Turbo Machine Company

Lansdale, Pa.

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Foundry Trade News

Continued from page 186

management accounting program.

Clyde B. Jenni, General Steel Castings Corp., was awarded the technical and operating medal in recognition of his contributions to the industry. Nino Davi



Clyde B. Jenni, left, General Steel Castings Corp., Eddystone, Pa., receiving S.F.S.A. technical and operating medal for outstanding contributions to the industry. Presenting award is **R. L. Gilmore,** S.F.S.A. president.

Pacific Steel Castings Co., won top honor for his technical paper, *A New Synthetic Sand Binder,* and John C. Wallfred, Minneapolis Steel Castings Co., won second place for his paper, *The Influence of Certain Additions on Sodium Silicate Bonded Sands.* Seven companies won safety awards for one year of operation without lost-time injury. They were: Tonawanda Electric Steel Casting Corp., Hughes Tool Co., Calumet Steel Castings Corp., Eastern Malleable Iron Co., Blaw-Knox Wheeling Works, Deemer Steel Casting Co. and American Cast Iron Pipe Co.

Pyrometer Co. of America, Inc. . . . Penndel, Pa., has appointed Clifford B. Ives & Co., Narberth, Pa., as representative in the Greater Delaware Valley area—including eastern Pennsylvania, south and central New Jersey and northern Delaware.

Handlebar Harry Has Been Found!

The oldest Simpson mix-muller entered in the National Engineering Co. contest is located in the foundry of Dominion Coal Co., Ltd., Glace Bay, Nova Scotia. Dubbed "Handlebar Harry," this muller was entered by William Phillips, foundry superintendent of the company. He and his wife win a 10-day, all-expense trip to Hawaii. The winning muller, purchased new by Dominion over 40 years ago, has been in continuous operation ever since. All the other prize winners will be officially announced at 11:45 am, May 11, at the National Engineering Co. Booth, AFS Exposition.



CHOOSE YOUR WEAPON

for WAR against the SCRAP PILE!

Guessing when to pour, or using inaccurate temperature measuring instruments, results in misruns, cold-shuts or leaving molds on the floor unpoured. Equip your foundry with dependable Marshall Enclosed-Tip Thermocouples for strong, dense, uniform castings from every melt!

MARSHALL THERMOCOUPLES OFFER THESE ADVANTAGES!

DEEP READING. Takes interior temperature deep within melt . . . tip can be immersed 3 inches or more in depth!

FAST RESULTS. Tip can be stirred to speed reading, giving true temperature in about 20 seconds!

ACCURACY. Pyrometer always indicates steady, accurate reading!

ECONOMY. Hot junction tip, armored with enclosing tube of special alloy, withstands scores of immersions before replacement is necessary!

FLEXIBILITY. Well-balanced thermocouple is convenient to carry and use, simple to operate!

TROUBLE-FREE. Has ruggedly designed parts for long-life reliability. Thermocouple wire can't be contaminated from melt or shortcircuited by slag!

CHOICE OF TYPES. Furnace Type (below, right) . . . lengths up to 10 feet for use with Stationary Pyrometer. Ladle Type (below, left) for use with Portable Pyrometer.





Write today for FREE catalog!

L. H. MARSHALL CO.
270 WEST LANE AVE., COLUMBUS 2, OHIO

Circle No. 172, Page 207

let's get personal



M. E. Brooks



J. R. Hersey



C. J. Neville

Manley E. Brooks . . . has been named to receive the 1960 David Ford McFarland award for achievement in metallurgy given by the Penn State Chapter of the American Society for Metals as an annual recognition to a metallurgy alumnus. Brooks is a consultant and foundry engineer of the Magnesium Dept., Dow Chemical Co. He will receive the award May 14 at University Park, Pa.

Jean-Pierre Polar . . . has been made assistant to the director of technical information for Climax Molybdenum Co., Div. American Metal Climax, Inc., in preparation for later service with the company's Zurich, Switzerland, operation.

Claude J. Neville . . . formerly executive vice-president and treasurer, has been elected president and general manager of C. O. Bartlett & Snow Co. **H. S. Hersey**, formerly president and general manager was elected to chairmanship of the board of directors. **John R. Hersey** was elected vice-president and treasurer; and **F. W. Neville** was named purchasing director and assistant secretary.

B. C. Yearley . . . AFS-Training & Research Trustee, and formerly assistant to the president, National Malleable & Steel Castings Co., Cleveland, has been appointed vice-president of the newly formed General Research, Development and Engineering Div. It will deal with metallurgical research, conduct process and product developments, perform general engineering services for plant and equipment layout and follow developments of the various technical societies.

John C. Harwood . . . formerly sales engineer, Elyria Foundry Div., Chromalloy Co., Chicago, is now sales engineer, Standard Foundry Co., Racine, Wis.

Roger H. Kottke . . . Minneapolis, has been promoted to group leader in charge of the Archer-Daniels-Midland Co. foundry research and development laboratory, succeeding **R. J. Mulligan,** recently appointed sales manager of the A-D-M Federal Foundry Div. Kottke, who has been a member of the A-D-M foundry products research staff since 1956, formerly was project leader in the foundry laboratory.

Kenneth Majors . . . has been appointed manager, customer service department, Standard Horse Nail Corp., New Brighton, Pa., succeeding **Jim Latham** who resigned.

Martin F. Scheider . . . is now foundry manager, White Diesel Engine Div., White Motor Co., Springfield, Ohio. He was formerly a principal in A. R. Posey Co., Cincinnati.

Howard F. Lewis . . . has been elected vice-president, Greenlee Foundries, Inc., Chicago. He was formerly a vice-president of Woodruff & Edwards, Inc., Elgin, Ill.

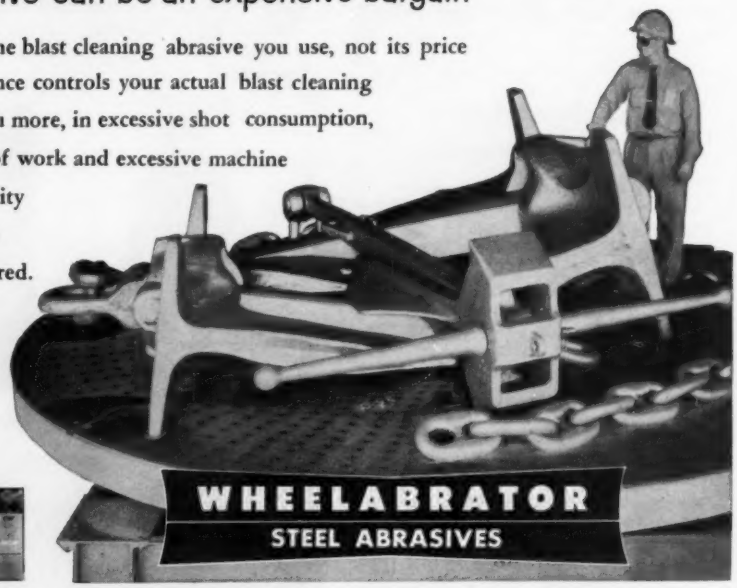
Terence P. (Terry) Brennan . . . formerly

EXECUTIVE REPORT #5

DON'T SAVE PENNIES TO LOSE DOLLARS

the lowest-priced abrasive can be an expensive bargain

Your real concern is the *ultimate cost* of the blast cleaning abrasive you use, not its price per ton. Abrasive quality and performance controls your actual blast cleaning costs. Lower priced abrasives can cost you more, in excessive shot consumption, lower production volume, poor quality of work and excessive machine maintenance. In case after case, high quality Wheelabrator Steel Shot has proven to be the *lowest-cost* abrasive, all factors considered.



You can prove the savings you'll make with Wheelabrator Steel Shot

Your Wheelabrator Abrasive Engineer will demonstrate the performance of Wheelabrator Steel Shot in your own plant. For helpful suggestions to get better cleaning at lower cost, write for our new Handbook of Abrasive Performance. Wheelabrator Corp., 630 S. Byrkit St., Mishawaka, Ind. In Canada, P.O. Box 490, Scarborough, Ontario.



Circle No. 173, Page 207



C. H. Cline



R. W. Griswold



W. M. Grimes



R. S. Hodler



J. W. Hallock



F. B. Rote

football coach at Notre Dame University, has joined Miller & Co., Chicago, as assistant to the vice-presidents and staff coordinator.

K. W. Stoops . . . Super Mold Corp., Stockton, Calif., has been made production superintendent of all plants.

John Balkey . . . formerly foundry foreman, Aetna Standard Div., Blaw-Knox Co., Elwood City, Pa., is now general foundry foreman at Strong Steel Foundry Co., Buffalo, N. Y.

C. H. Cline . . . formerly foundry superintendent, H. G. Enderlein Co., Philadelphia, has joined the New Jersey Department of Labor and Industry.

R. W. Griswold . . . a past director of AFS and formerly factory manager, Erie Malleable Iron Co., Erie, Pa., has been promoted to president and general manager. **P. H. Vincent**, formerly president and general manager, is now chairman of the board. **B. H. Scott** has been named vice-president in charge of sales.

James W. Hallock . . . has advanced to vice-president in charge of sales, Albion Malleable Iron Co. **Dr. Franklin B. Rote** was named vice-president, technical director. **Arnold A. Behling** was made controller. Albion operates malleable foundries at Albion, Mich., and Muncie, Ind., the latter a recent acquisition.

Paul D. Terrien . . . has been named as sales representative for the midwest area and will coordinate sales of the Great Lakes Carbon Corp., Electrode Div. He formerly served in the same capacity in the Pittsburgh office. **Donald J. Palmisano** has been named sales engineer, specialties, at Kansas City. He formerly served as sales representative at the same location.

H. Earl Love . . . has moved up to assistant sales manager, eastern division, Pyrometer Co. of America, Penndel, Pa. He has been with the Pyrometer company since 1958 and formerly handled the local Philadelphia sales office.

William M. Grimes . . . has become president, Gartland Foundry Co., Terre Haute, Ind., **R. S. Hodler**, formerly of Golden Foundry Co., Columbus, Ind., has been made vice-president and general manager.

Jess Toth . . . Chairman of the AFS Education Division and formerly sales manager, Harry W. Dietert Co., Detroit, has

EXECUTIVE REPORT #16

HOW MANY TRIANGLES* CAN YOU FIND IN THIS STAR?

Look for the hidden value in blast cleaning abrasives, too



The "hidden values" you get in a high quality steel abrasive, like Wheelabrator Steel Shot, far outweigh any price advantage of the so-called "economy" abrasives. Wheelabrator Steel Shot is harder and tougher — lives for many more cycles through your blast equipment. It cleans better — allows shorter blast cycles. You'll get better, faster cleaning, lower maintenance, lower actual cleaning costs with top quality Wheelabrator Steel Shot. Thousands of users do. Your Wheelabrator Abrasive Engineer will prove it.

Write today for this new handbook of blast cleaning abrasive performance, full of charts and facts to help you control abrasive consumption and reduce cleaning costs. Write to **Wheelabrator Corp., 630 S. Byrkit St., Mishawaka, Ind. In Canada, Wheelabrator Corp., Canadian Div., P.O. Box 490, Scarborough, Ontario.**

WHEELABRATOR
STEEL ABRASIVES

**If you examine it closely enough, you'll find 97 triangles.*

Circle No. 174, Page 207



Produce BETTER CASTINGS

with *Laboratory Tested*

FOUNDRY MATERIALS

SAND

Portage (Wis.) Silica
Century Molding
*Ottawa Blackhawk Silica
Muskegon Lake Sand
Tenn. & Ind. Molding
Utica Crude Silica
Green Lake & St. Marie Shell
*Zircon Sand, Flour and Wash
Berlin Core Sand
Red Flint Annealing & Packing
New Jersey Molding
Gallia Red Molding
Albany Molding
Olivine Sand and Flour
Gopher State Silica

BONDING CLAYS

*Volclay, MX-80 (Granular)
*and Panther Creek Bentonite
*Goose Lake Fire Clay
*Grundite Bonding Clay
Goose Lake Castables

ABRASIVES

*Tru-Steel Steel Shot
Mallan' Steel Shot and Grit
*Mallebrasive Shot and Grit
*Certified Shot and Grit
*Blackhawk Sand Blast Sand
*Super-Titan Nozzles

REFRACTORIES & MISC.

Cupola Gun Mixes
Firegun Ganister
*Microsil Silica Flour
Fluxing Limestone
*Five Star Wood Flour
*Sultron Foundry Flux
Iron Oxide-Fluorspar
Cellflo Flour

* Whse. Stocks carried

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608 Lake Drive
Tel. SH. 4-1589

Circle No. 175, Page 207

Let's Get Personal

Continued from page 191

been advanced to vice-president and secretary of the company.

James M. Lange . . . has transferred to the position of sales development engineer, Chas. Taylor & Sons Co., Cincinnati. He was previously associated with Bethlehem Steel Co., Bethlehem, Pa.

Harry F. Derstler . . . has assumed duties of purchasing agent for the Columbia, Pa., plant of Grinnel Corp., following the retirement of **Fred F. Radcliffe.**

John G. Ziemann . . . has been named chief metallurgist, Metals Div., Kelsey-Hayes Co. He joined Kelsey-Hayes in 1957 and was named assistant chief metallurgist in 1959.

Harold A. Moffat . . . has been appointed salt bath furnace specialist with Lindberg Engineering Co., Chicago. Moffat, who will headquarter in Los Angeles, previously was responsible for sales and installation of scientific apparatus and heat treating furnaces in Ohio and Pennsylvania.

Harold E. Britton . . . foundry management consultant, Northbrook, Ill., has been appointed as consultant on management techniques and economic problems for the Iranian Oil Co., Abadan, South Iran. He will work with British, Dutch, French and American oil companies operating the oil fields and refineries for the Shah of Iran.

Earl F. Kindinger . . . has been named manager of the new foundry department of Williams & Co., Pittsburgh, Pa. **Fred J. Culbert** has been named as manager of the inventory department assisted by **William A. Hunt** as supervisor.

William J. Feahr . . . has been named divisional manager of the Crouse-Hinds Co., Great Lakes Div., Cleveland. He joined the company as a project engineer in 1948. **Chester C. Pratt** has become regional manager for Crouse-Hinds operations in Detroit. He was formerly a product engineer in Buffalo, N. Y., joining the company in 1950. **Walter A. Short,** formerly a product engineer in the Boston region, has been transferred to Buffalo, N. Y. He joined the company in 1946.

Jack L. Martin . . . has been appointed manufacturing engineering manager of Superior Foundry, Inc., Cleveland, and the Allyne-Ryan Div., Cleveland. He was associated with James B. Clow & Sons as management consulting executive. **Daniel J. Gentile,** has joined Superior Foundry, Inc., as an industrial engineer. He was formerly associated with Wellman Bronze & Aluminum, Inc.

Continued on page 194

HIGH CARBON STEEL WIRE SHOT

MORE REGULAR SURFACING—LONGER LASTING
LOWER EXPOSURE TIME—RESULTING IN
LESS WEAR AND TEAR ON MACHINERY
INCREASED PRODUCTION—LOWER LABOR COST

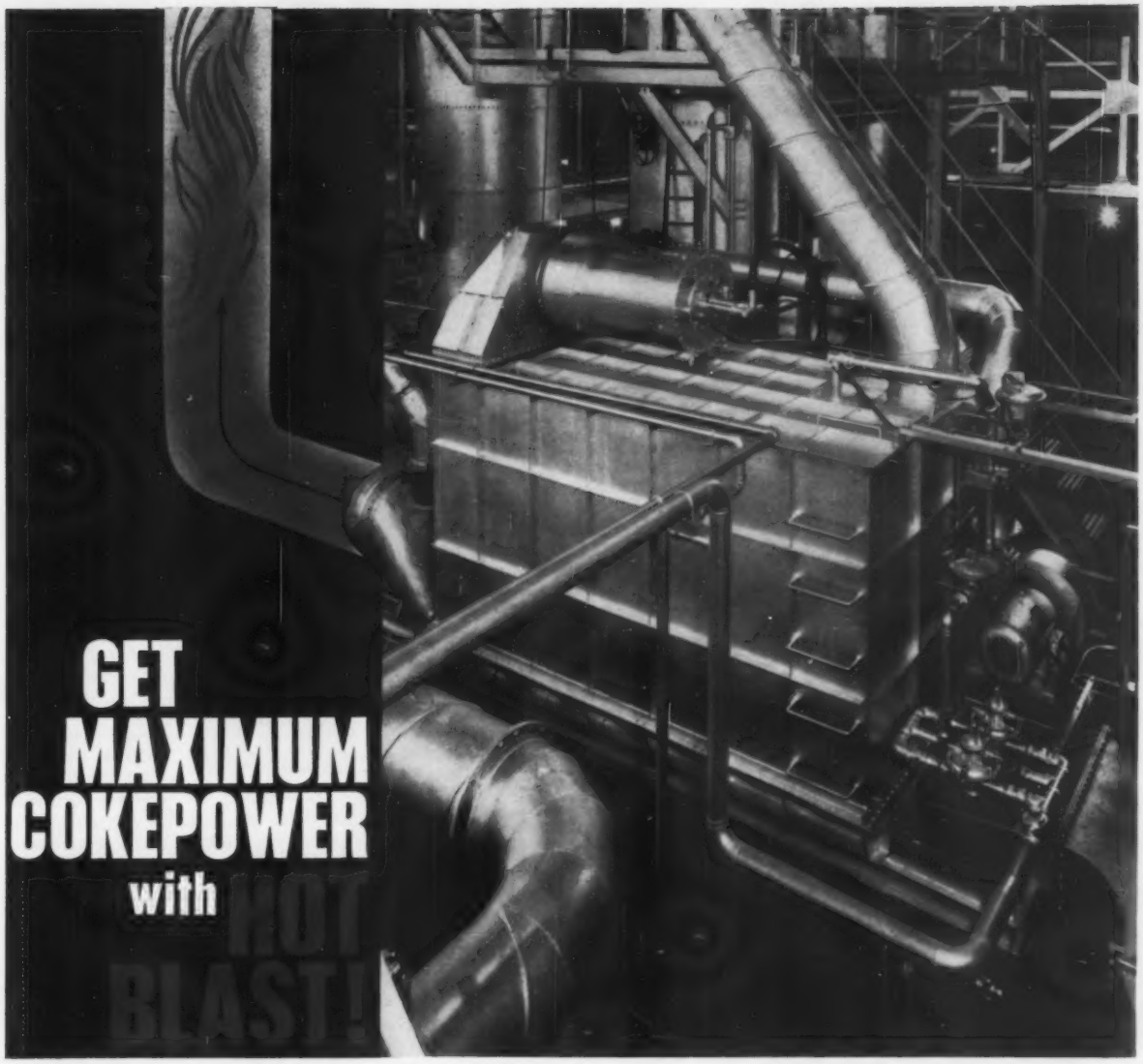
For Information Write or Phone

BEKAERT STEEL WIRE CORP.

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TERRITORIES AVAILABLE TO QUALIFIED DISTRIBUTORS
SEE US AT BOOTH 238
AFS FOUNDRY CONGRESS, MAY 9-13, PHILADELPHIA, PA.

Circle No. 176, Page 207



Save coke . . . melt hotter iron . . . Hot Blast will do this for you! Whiting Hot Blast gets more heat out of coke . . . ignites it faster. Tuyeres keep clean and unobstructed, provide better control of melt. Oxidizing zone is reduced and oxidation losses are cut. And less coke means less sulphur in the melt!

Hot Blast more than pays for itself in *coke savings alone!* Better quality, hotter iron are bonus benefits. Investigate Hot Blast now. Call in a Whiting Foundry Engineer!



FREE BOOKLET . . . Gives sharp insight into Hot Blast advantages; describes operation of two major types. Write for Bulletin FO-3. *Whiting Corporation, 15607 Lathrop Avenue, Harvey, Illinois*

FEMA

COST-SAVING EQUIPMENT...THE WAY TO HIGHER PROFITS

FOUNDRY EQUIPMENT

WHITING

MANUFACTURERS OF CRANES; TRAMBEAM HANDLING SYSTEMS; TRACKMOBILES; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

Circle No. 177, Page 207

Let's Get Personal

Continued from page 192

Sheldon W. Hughes . . . after more than 35 years in the foundry industry, resigned in March from Hale Fire Pump Co., Conshohocken, Pa., where he had been foundry superintendent.

Curtis J. Sears . . . formerly industrial engineer, Bucyrus Erie Co., Milwaukee, is now industrial foundry engineer for Winters Foundry & Machine Co., Canton, Ohio.

Woodrow W. Holden . . . formerly plant manager, Dostal Foundry & Machine Co., Pontiac, Mich., is now foundry engineer, Pickands-Mather & Co.

James R. Reid . . . until recently a mechanical engineer, James B. Clow & Sons, Inc., Birmingham, Ala., is now with Rust Engineering Co., Birmingham.

D. J. Anzells . . . previously quality control engineer, Forest City Foundries, Cleveland, is now with Millwood Mfg. Co., Cleveland.

Ted. V. Linabury . . . and **Lester A. Berkholtz** have joined Miller & Co. Chicago. Linabury joins as a sand consultant and is based in Chicago. Berkholtz is resident manager of the Wisconsin and northern Michigan district and is based in Milwaukee.

obituaries

James G. Goldie, 58, died March 6 in a Cleveland hospital. Goldie was born in Scotland and was a graduate of Glasgow Technical College, coming to the United States in 1923. For 29 years he was a teacher for the Cleveland School Board, serving 16 years as head of the foundry division until 1946 when he joined M.B.M. Foundry, Inc., Cleveland, as foundry superintendent, returning to the Cleveland Trade School in 1950. He retired two years ago because of ill health. Goldie served as chairman of the Northeastern Ohio Chapter 1943-44 and was active in apprentice work, both on AFS national committees and for the Northeastern Ohio Chapter. He instituted the foundry school in the Cleveland Trade School and the new Max S. Hayes Trade School, an outgrowth of the former, and participated in installing the first working school exhibit at AFS national conventions in 1938 and 1942.



J. G Goldie

Frank Valtier, 89, a collaborator on many AFS technical papers and a participant in the developing and improving of many sand testing units, died March 7 in Toledo, Ohio. He was born in Strassburg, Germany, and was a foundry engineer with General Motors Corp. from 1920 to 1929 and with the Harry W. Dietert Co. from 1929 to 1935. For the next three years he was associated with the Nash Kelvinator Co. and returned to the Dietert Co. from 1938 to his retirement in 1956.

Victor W. Hain, associated with Frederic B. Stevens, Inc., for 15 years as foundry sales representative in western Michigan, died March 17. Previously he had been foundry manager for Premier Furnace Co., Dowagiac, Mich.

Lloyd C. Farquhar, Sr., 72, retired works manager of American Steel Foundries, East St. Louis, Ill., and AFS Director 1949-1952, died April 4. He started his career with American Steel Foundries in 1910 at Granite City, Ill., followed by three years with Allegheny Steel Co. prior to serving for three years in World War I as a captain. He rejoined American Steel Foundries in 1920 as assistant works manager, becoming works manager in 1939.



L. C. Farquhar

W. T. Sheffield, who retired several years ago from Fuller Co., Manheim, Pa., died recently at his Florida home.

A. J. Riley, owner of Riley Foundry Works, Charleston, S.C., died March 19 in Charleston.

Sydney McGinty, 51, sales representative, died March 21 near Kankakee, Ill., in the crash of his light airplane. McGinty was employed as a metallurgist by Burnside Steel Co., Chicago, from 1936 to 1942, when he formed his own business, Firegan Sales Co., Oak Park, Ill.



S. McGinty

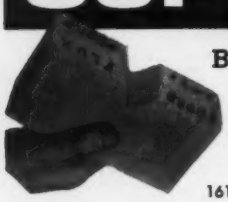
J. E. McCauley, 77, former chairman of the board of directors and chief executive officer, Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., died at his home Feb. 28. He joined the company in 1910 as assistant general manager, became vice-president and general manager in 1919, president in 1934, retiring in 1955 as chairman of the board and chief executive officer.

FROM NEW ENGLAND TO TEXAS

and over the length and breadth of Canada, gray iron and ductile foundrymen are using SUPERFLUX in their cupolas, and LADLE FLUX in their alloying ladles and are getting "bang-up" results.

Let us widen your margin of profit by giving you better castings and smoother operations.

SUPERFLUX®



Briquetted Cupola Flux

SUPERFLUX MFG. CO.

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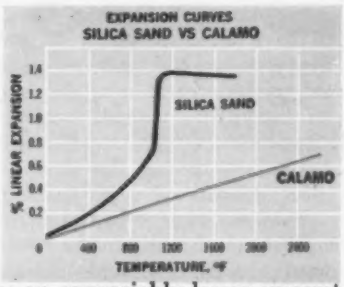
HICKMAN, WILLIAMS & CO. Philadelphia New York Cleveland Pittsburgh

SCOTT BRIQUETTED PRODUCTS Welland, Ontario

Circle No. 178, Page 207

FOR BETTER METAL CASTING... HARBISON-WALKER REFRACTORY MOLD MATERIALS

Calamo for investment molds



CALAMO, one of the extensively used Harbison-Walker products for molding, is an alumina-silica refractory of optimum sizings for various molding mixtures. Its fusion point is 100°F. higher than that of normal silica sand mixes.

The chart shows the exceedingly desirable expansion curve of CALAMO compared with that of silica.

CALAMO, used as the major constituent of precision casting investment mixes, improves dimensional constancy of molds, makes them stronger and more resistant to erosion by metal flow.

Investment costs are measurably reduced because an appreciably lesser amount of bonding agent is needed. This is attributable to the very desirable particle sizing and the equiaxed, dense grains of CALAMO.

CALAMO, used alone or as the major part of conventional dry sand molding mixes in rammed, or in slinger-place sand molds, provides not only the very desirable low thermal expansion particularly suited for precision casting but also the refractoriness for metals and alloys melted at unusually high temperatures.

H-W Flintgrain

for ceramic shell molds

H-W FLINTGRAIN is an alumina-silica refractory, similar in composition to CALAMO, having the same very desirable low thermal expansion characteristics, but greater angularity of grain shape.

The angular grain shape and optimum size distribution make H-W FLINTGRAIN ideal for securing maximum compactness in the mold. It is used with special benefit for making ceramic shell molds and for similar applications in which dense, compact mold sections of greatest volume stability at all temperatures, are of paramount importance.



Illustration of angulate shape of H-W Flintgrain enlarged x3

H-W Moldsand Bond

H-W MOLDSAND BOND is a highly refractory clay having unusual plasticity and bonding strength for conventional molding. Used alone or with other binders, it imparts enhanced hot strength to molds and in some mixes replaces, wholly or in part, binders of higher cost. It is used with equally good results for the usual rammed mixes with sand or CALAMO. Molding mixes made with H-W MOLDSAND BOND have decidedly improved storage properties.

HARBISON-WALKER REFRACTORIES CO.

AND SUBSIDIARIES

GENERAL OFFICES: PITTSBURGH 22, PA.

World's Most Complete Refractories Service

Circle No. 179, Page 207



Pangborn Plane Service

Visitors at the AFS Castings Congress & Exposition will have an opportunity to inspect Pangborn Corp., Hagerstown, Md. production facilities laboratories and machinery not being displayed at the Show. A fleet of three planes, recently acquired by Pangborn on charter-contract agreement will make several round trips daily during the show.

The fleet consists of a six-passenger E-18 Super Beech, a five-passenger Aero Commander and a four-placeplace Beech Bonanza. They were acquired by Pangborn Primarily to provide more rapid and convenient customer service, and will also be used to transport prospective customers to Hagerstown for confeernces and equipment demonstrations. Because of the proximity of the Show, the fleet will be used to furnish this additional service.

Polish metallurgical samples
easier, better, more uniform with . . .

SYNTRON



LAPPING-
POLISHING
MACHINES

—whether it's one or a number of specimens to be polished, SYNTRON Vibratory Lapping-Polishing Machines will produce a metallographic finish for an electron microscope or brush analyzer examination.

Gentle, electromagnetic vibration moves the specimens smoothly around the pan, over abrasive cloth or polishing felt cloth. Abrasive cloths are removable.

SYNTRON Lapping-Polishing Machines are easy to install, easy to operate, easy to maintain.

Write for detailed literature today

SYNTRON COMPANY
Quality Equipment Since 1931
545 Lexington Ave. Homer City, Penna.

Circle No. 181, Page 207

Griffin Wheel Co. Opens Cast Iron Pipe Foundry

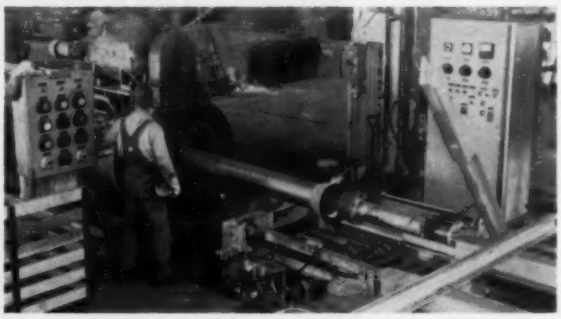
Griffin Wheel Co., Chicago, has announced that its cast iron pressure pipe plant in Council Bluffs, Iowa, has been completed and is in full production. The opening of the plant marks the entry of Griffin into a new field. Griffin's other principal product line is freight car wheels for railroads.

The Chicago firm formerly used the Council Bluffs plant to produce iron wheels. Conversion of the plant into a modern pipe producing facility was begun in April, 1959.

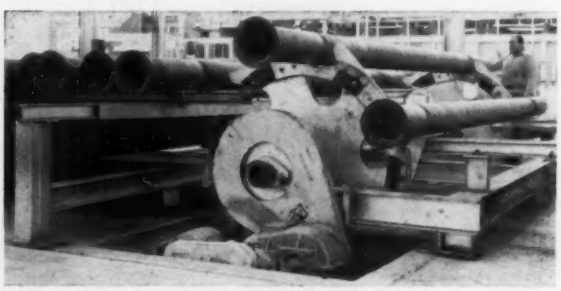
Griffin pipe is cast in 20-foot lengths with diameters of 4 in. to 12 in. by the Delavaud process of centrifugal casting. This process uses centrifugal force to distribute molten metal within a permanent, water-cooled, revolving steel mold. The new Griffin plant is the only pipe plant in the nation to produce the 20-foot length of iron pressure pipe in the 4-in. to 12-in. diameter size range by the Delavaud process.

The Council Bluffs plant consists of 95,000 square feet of buildings on 19 acres of land with a separate office building. The site is served by nine railroads and truck carriers.

Including the pipe plant, Griffin operates 11 plants in the United States and Canada and a research center at Bensenville, Ill. Griffin is a subsidiary of American Steel Foundries, Chicago.



A red-hot 20 ft length of cast iron pressure pipe is pulled from one of the three centrifugal casting machines. Below is pictured a revolving ferris wheel which sorts pipes according to diameter. Wheel eliminates sorting and transferring pipe by crane. The Council Bluffs plant was formerly used to produce iron wheels for railroad freight cars, the principal product of the Griffin company. Conversion of the plant was started in April, 1959.



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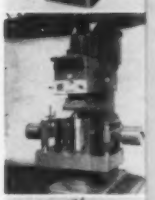
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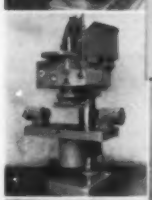
THE ROEPERWERK IS A LICENSED MANUFACTURER OF HANSBERG SHOOTERS. ALSO MANUFACTURERS KOMAX Co2 HARDNESS. ROLLOVERS AND OTHER FOUNDRY EQUIPMENT. THE ROEPERWERK IS THE LARGEST MANUFACTURER OF CORE MAKING MACHINES. ROEPERWERK HANSBERG CORE SHOOTERS HAVE OUTMODED CORE BLOWERS IN EUROPE AND ARE FAST BECOMING THE FAVORED CORE MAKING MACHINES OF THE AMERICAN FOUNDRYMEN ALSO.



H-25 R Hansberg Core Shooter



H 25 R Hansberg Shooter combined with CO2 hardener. Shoots and CO2 hardens cores in one clamping.



H 12 R Hansberg Shooter combined with CO2 hardener.



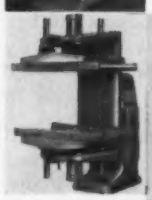
D-OA Hansberg Core Shooter and automatic CO-2 hardener



KOMAX CO2 HARDENER bench model for small cores.



KOMAX CO2 HARDENER floor model for large cores or molds.



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HIGHEST EFFICIENCY IN CORE PRODUCTION WHEN USED WITH THE NEW COLLAPSIBLE CO-2 CORE BINDERS!



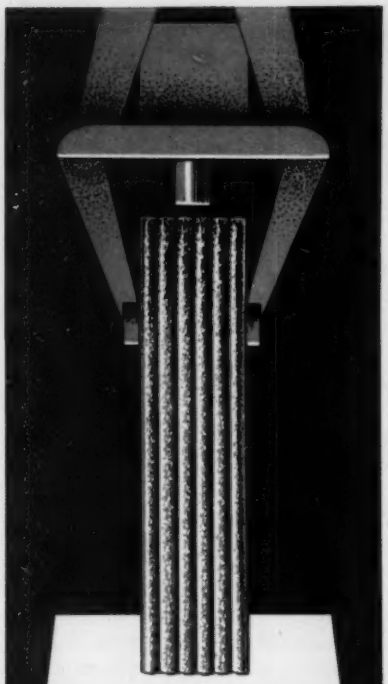
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Circle No. 182, Page 207



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PQ PLANTS: ANDERSON, IND.; BALTIMORE, MD.; BUFFALO, N.Y.; CHESTER, PA.; JEFFERSONVILLE, IND.; KANSAS CITY, KANSAS; RAHWAY, N.J.; ST. LOUIS, MO.; UTICA, ILL.

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Russian Foundry News . . .

is quite comparable to current American technology and well worth watching for new ideas. Statements and claims in these items about USSR metalcasting developments appeared in abstracts prepared by the Office of Technical Services, U. S. Department of Commerce, Washington, D. C.

■ Crushed cast iron scrap with diameter range of 1-1.5 mm is being used instead of sand as a molding material for casting iron brake components.

■ Sheet metal crucibles coated with a special heat-resistant enamel are claimed to be satisfactory for handling molten aluminum alloys. Enamel composition is: 63.32% SiO_2–2.81% Al_2O_3–4.75% CaO–16.11% Na_2O–1.7% B_2O_3–4.27% TiO_2–4.19% K_2O–2.0% CaF_2–0.42% Cr_2O_2–0.32% CaO–0.11% NiO.

■ Liquid metal stamping has been developed in Russia as another way of producing metal shapes. Molten metal is poured in die and then stamped to final shape.

■ Malleable iron is being made with 0.002 per cent boron and 0.003 per cent bismuth content. As a result fluidity increases 7 per cent and annealing time drops 27 per cent.

■ Thick-walled (over 1.5 in.) malleable iron castings are made possible by addition of 0.005-0.020 per cent creased to 2.5 per cent or more, thereby shortening anneal time to 34 hr for ferritic malleable. Use of magtellurium. Silicon content can be innesium shortened this time to only 18 hr. This malleable iron can also be cold stamped.

■ Oxygen is being used to remove silicon from iron in reverberatory furnaces before casting into chilled rolling mill rolls.

■ Thermal treatment of liquid aluminum alloys raises tensile strength and elongation a remarkable degree. Aluminum alloys containing either 9% Cu, 10% Mg, 5% Fe, 5-7% Si or 10-11% Si are all similarly affected. Thermal treatment consists of holding the metal molten for 25-30 minutes in furnace before pouring.

■ Russian motorcars are having considerable success with aluminum pistons, provided the aluminum alloy used meets certain specifications. Cracking has been eliminated by keeping copper content up in the range 6.25-8.00 per cent and silicon at 5.0-6.0 per cent. Balance of aluminum alloy contains 0.2-0.5 per cent Mg, 1.5 per cent Fe, 0.6 per cent Zn, 0.5 per cent Mn and 0.5 per cent Ni. Maintaining the copper and silicon on the high side improved the alloy's casting properties, reduces its thermal expansion and increases resistance to heat.

■ Silicon metal castings are being used in Russia for corrosive applications as high as 1110 F. Silicon is induction melted and poured at 2910 F into ceramic or graphite molds. An argon protective atmosphere is used during pouring to prevent formation of SiO_2. Castings are so hard that ultrasonic machining proves most satisfactory.

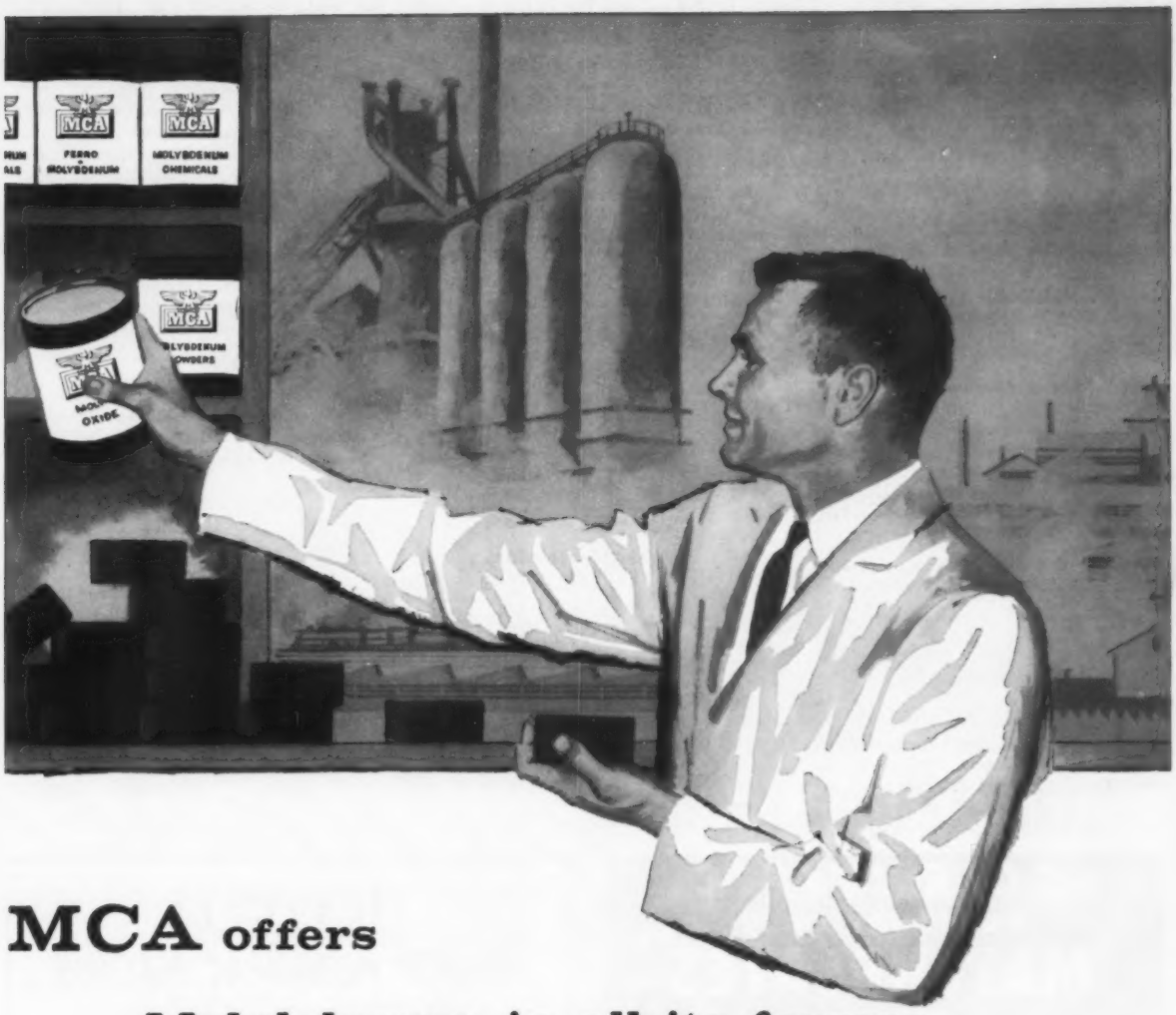
■ Coke substitute for cupolas is coal particles fortified with coal-tar pitch and briquetted at 150 kg/cm² pressure. Briquettes are given thermal treatment at 1832 F. This fuel increased cupola metal temperature to 2640 F and output by 20 per cent.

■ Gray cast iron is being tapped from cupola and then inoculated with molten steel produced in side-blast converter. Increased flexural strength, deflection and hardness are among the improved physical properties claimed by this liquid metal inoculation process.

NATIONAL FOUNDRY ADVISORY COMMITTEE REPORT

Studies by Bureau of Apprenticeship and Training indicate a need for manpower with more skill and higher standards of performance. In most instances increased productivity will be achieved through mechanization and new technology. Higher worker efficiency will be necessary to profit by these new methods. Also maintenance mechanics will be in greater demand. Some increase in employment will be necessary for these new employees as well as the old must be trained.

The training of patternmakers, foundry technicians, maintenance electricians and mechanics should be started now if they are to be skilled in 1960.



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MCA

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future meetings and exhibits

May 3-5 . . Iron and Steel Institute, Annual Meeting. London, England.

May 6 . . Malleable Founders Society, Eastern Section Meeting. Hotel Commodore, New York.

May 9-12 . . Instrument Society of America, Instrument-Automation Conference. San Francisco.

May 9-13 . . AFS 64th Annual Castings Congress & Exposition. Convention Hall, Philadelphia.

May 9 . . Investment Casting Institute, Design Clinic. Essex House, Newark, N. J.

May 12 . . National Castings Council, Annual Meeting. Warwick Hotel, Philadelphia.

May 17-19 . . American Society of Mechanical Engineers, Production Engineering Conference. Milwaukee.

May 22-26 . . Air Pollution Control Association, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

May 23-26 . . American Society of Mechanical Engineers, Design Engineering Show. Coliseum, New York.

May 23-31 . . Magnesium Association, Annual Meeting. London and Manchester, England and Hannover, Germany.

May 24-26 . . American Society for Quality Control, Convention. San Francisco.

May 25-26 . . American Iron and Steel Institute, General Meeting. Waldorf-Astoria Hotel, New York.

June 5-9 . . American Society of Mechanical Engineers, Summer Annual Meeting & Aviation Conference. Statler Hilton Hotel, Dallas, Texas.

June 6-8 . . Material Handling Iistitute, New England Show. Commonwealth Armory, Boston.

June 6-8 . . Malleable Founders Society, Annual Meeting. Elbow Beach Surf Club, Hamilton, Bermuda.

June 9-10 . . University of Wisconsin and AFS Wisconsin Chapter, Engineering Institute. War Memorial Center, Milwaukee.

June 14-17 . . Cornell University Industrial Engineering Seminar. Cornell University, Ithaca, N. Y.

June 16-17 . . AFS Chapter Officers Conference. AFS Headquarters, Des Plaines, Ill., and LaSalle Hotel, Chicago.

June 19-21 . . Alloy Casting Institute, Annual Meeting. The Homestead, Hot Springs, Va.

June 26-July 1 . . American Society for Testing Materials, Annual Meeting & Exhibit. Chalfonte-Haddon Hall, Atlantic City, N. J.

June 27-July 1 . . Gordon Research Conferences, Physical Metallurgy-Relation of Structure & Properties. Kimball Union Acaremy, Meriden, N. H.

Sept. 14-15 . . American Die Casting Institute, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 6-16 . . National Machine Tool Builders' Association, Machine Tool Exposition. International Amphitheatre, Chicago.

Sept. 19-24 . . International Foundry Congress. Zurich, Switzerland.

Sept. 22-23 . . National Foundry Assoc-

Continued on Page 203



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Circle No. 185, Page 207

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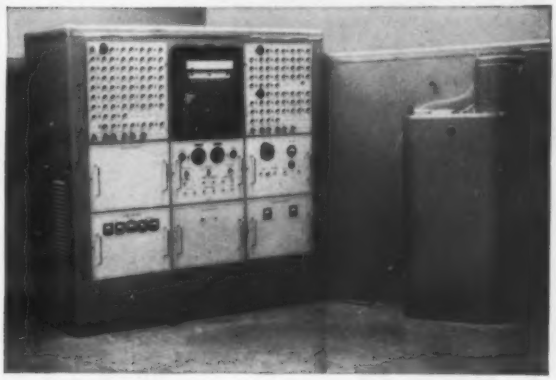


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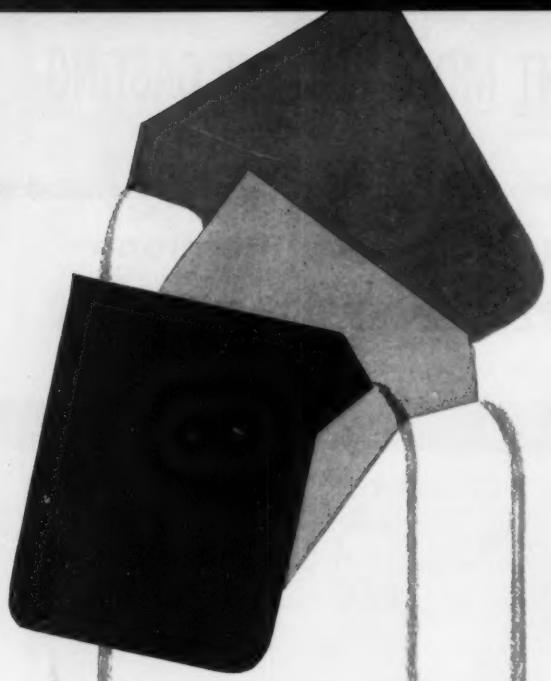
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Whether your foundry is large or small, your production runs long or short . . . you can have modern, automatic core and mold production for a surprisingly modest investment in Sutter equipment.

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Future Meetings

Continued from page 200

iation, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 27 . . American Management Association, Annual Meeting. Hotel Astor, New York.

Sept. 27-30 . . Association of Iron and Steel Engineers, Annual Convention & Exposition. Public Auditorium, Cleveland.

Oct. 12 . . Cast Bronze Bearing Institute, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 12-14 . . Gray Iron Founders' Society, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

Oct. 13-15 . . Non-Ferrous Founders' Society, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 17-18 . . Magnesium Association, Annual Convention. Pick Carter Hotel, Cleveland.

Oct. 17-21 . . American Society for Metals, Annual Meeting and Metal Exposition & Congress. Trade & Convention Center, Philadelphia.

Oct. 17-21 . . National Safety Council, National Safety Congress. Chicago.

Oct. 19-21 . . National Management Association, Annual Meeting. Dinkler Hotel, Atlanta, Ga.

Oct. 20-22 . . Foundry Equipment Manufacturers Association, Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Nov. 14-16 . . Steel Founders' Society of America, Technical & Operating Conference. Carter Hotel, Cleveland.

Nov. 27-Dec. 2 . . American Society of Mechanical Engineers, Annual Meeting. Statler Hotel, New York.

Nov. 30-Dec. 2 . . Metallurgical Society of AIME, Electric Furnace Conference. Morrison Hotel, Chicago.

Dec. 6-8 . . National Association of Manufacturers, Annual Meeting. Waldorf-Astoria Hotel, New York.

Dec. 12-14 . . Material Handling Institute, Annual Meeting. Savoy-Hilton Hotel, New York.

1961

March 13-14 . . Steel Founders' Society of America, Annual Meeting. Drake Hotel, Chicago.

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NATIONAL has learned to control its melts to such a fine point, that we are able to turn out abrasives with controlled characteristics and predictable results ton after ton after ton. **PERMABRASIVE®**, the pearlitic malleable abrasive, annealed practically a pellet at a time, is enjoying a ten year record of saving money for thousands of cost-conscious customers.

Here's what this means: If you are using steel abrasives, **PERMABRASIVE®** can save you money, because of its faster cleaning action and lower cost per ton. If you are using ordinary annealed abrasives you can save money by buying **PERMABRASIVE®**, because of its faster cleaning action, minimum graphitic carbon, and longer life, because of its low phosphorus content. And—where special problems call for a custom-designed abrasive—NATIONAL can and does produce it, because of a decade of experience in the fine art of controlling its melts. Simply put: our metallurgists KNOW what it takes to get certain results and KNOW how to build it into our shot and grit.

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We also make **PERMA-STEEL®**, the low cost "work-horse" of the long-life abrasives, which may fit your special operation perfectly to produce many of the same cost-cutting advantages. If you have an application that calls for a chilled iron shot and grit, try our **CONTROLLED "T"®**, the "iron fist in a velvet glove." In short, NATIONAL makes an abrasive to cover every possible blast cleaning need.

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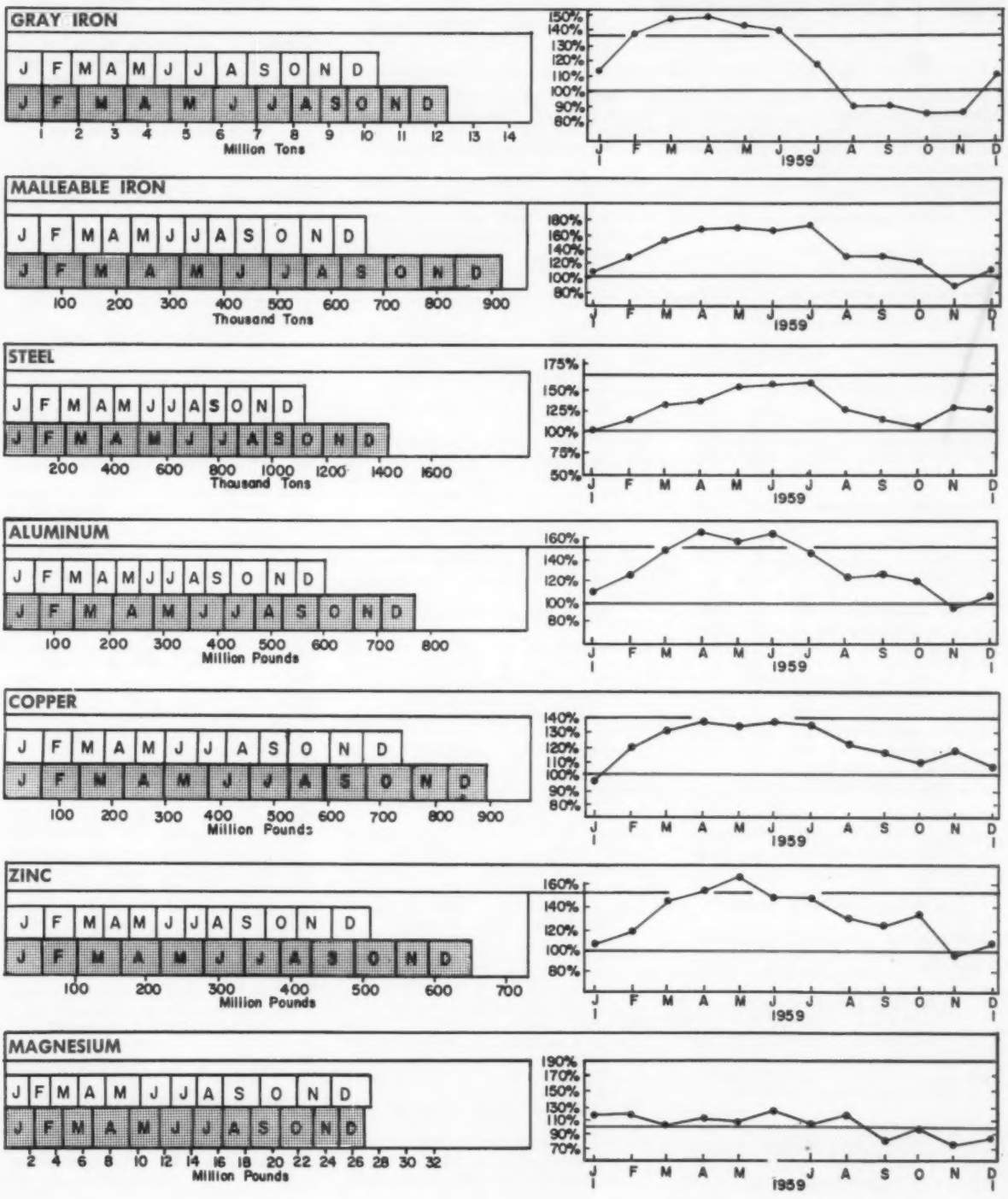
Circle No. 191, Page 207

How's Business . . .

MODERN CASTINGS has prepared this special comparison of month-to-month metalcasting shipments for 1958 and 1959, using statistics provided by the Bureau of Census, Department of Commerce. On the left, horizontal bar charts give a direct comparison of each month for the two years and the accumulative total for the 12-month period.

The right-hand set of graphs show shipments for each month of 1959 compared with the corresponding month in 1958, and the ratio converted to per cent. For example, gray iron shipments were 868,255 tons in January, 1958, and 1,001,771 tons in January, 1959—about 115 per cent of the 1958 rate. So the curve starts at 115 per cent and returns to 110 per cent for December, 1959, when shipments of 1,110,834 tons were slightly higher than the 997,608 tons shipped in December, 1958.

KEY---1958 1959



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For Your Copy, Circle No. 31, Page 207

Engineering achievements . . . during 1959 is subject of annual publication now available, tracing engineering advance and expansion. Allis-Chalmers.
For Your Copy, Circle No. 32, Page 207

Foundry sands . . . described in brochure. Wedron Silica Co.
For Your Copy, Circle No. 33, Page 207

Aircraft steels . . . detailed as to mechanical and physical properties in 24-p booklet. Allegheny Ludlum Steel Corp.
For Your Copy, Circle No. 34, Page 207

Microscopic examination . . . of metallurgical samples is reportedly made easy with lapping-polishing machines discussed in new catalog. Syntron Co.
For Your Copy, Circle No. 35, Page 207

Ferrous metallurgy guide . . . offers principal characteristics of steels represented across the temperature range to 2900 F. Tempil Corp.
For Your Copy, Circle No. 36, Page 207

Ductile irons . . . booklet, 28 pp, is complete with information, applications and specifications of these new cast metals. International Nickel Co.
For Your Copy, Circle No. 37, Page 207

Attract customers . . . build customer and employee loyalty, and other aspects of public relations covered in new booklet. Offers 33 basic ideas. Action Advertising Corp.
For Your Copy, Circle No. 38, Page 207

Malleable iron . . . facts and uses discussed in bulletin featuring use of malleable iron in 1960 automobiles. Malleable Founders Society.
For Your Copy, Circle No. 39, Page 207

Use a hand camera . . . to take photomicrographs. Read this bulletin to learn how easy it really is. Eastman Kodak Co.
For Your Copy, Circle No. 40, Page 207

Non-ferrous metal . . . melting furnaces featured in bulletin including pot furnaces, crucible furnaces, double chamber hearth furnaces and large capacity reverbatory furnaces. Hevi-Duty Div., Basic Products Corp.
For Your Copy, Circle No. 41, Page 207

Metal working facilities . . . for manufacture and processing of magnesium and aluminum rolled and extruded products, sand and permanent mold castings, die castings and fabricated assemblies described. Dow Metal Products Co., Div. Dow Chemical Co.
For Your Copy, Circle No. 42, Page 207

Molding sand . . . production facilities and operations presented in folder offering large "postcard" photographs. New Jersey Silica Sand Co.
For Your Copy, Circle No. 43, Page 207

Temperature-sensitive . . . crayons which melt at indicated temperatures include new temperature ratings developed during last year. Send for instructions. Tempil Corp.
For Your Copy, Circle No. 44, Page 207

1959 Index . . . to MODERN CASTINGS is available. American Foundrymen's Society.
For Your Copy, Circle No. 45, Page 207

Crawler-mounted . . . shovel cranes in 1/2 to 3-yd, 8 to 75-ton capacities featured in bulletin; pictures models, shows applications. Link-Belt Co.
For Your Copy, Circle No. 46, Page 207

Investment casting . . . process fully explained in 2-p brochure. Alloy Steel Casting Co.
For Your Copy, Circle No. 47, Page 207

Technical development . . . and quality control laboratory for small manufacturing plants is subject of government bulletin; learn how to start one for your plant. Small Business Administration.
For Your Copy, Circle No. 48, Page 207

Wall chart . . . depicting 10 "Do's" and 10 "Don'ts" of grinding wheel safety. Carborundum Co.
For Your Copy, Circle No. 49, Page 207

Meehanite castings . . . covered in 32-page booklet listing scope of applications. Also offers table of physical properties. Meehanite Metal Corp.
For Your Copy, Circle No. 50, Page 207

Metalcasting technology . . . experts have written many books and manuals which are available through AFS. A complete, classified list is yours when you use the circle number below. American Foundrymen's Society.
For Your Copy, Circle No. 51, Page 207

Wage picture . . . highlights during 1958 pointed out in government press release. Bureau of National Affairs, Inc.
For Your Copy, Circle No. 52, Page 207

Machining aluminum . . . booklet contains charts and specifications for all aspects of machining this metal. Reynolds Metals Co.
For Your Copy, Circle No. 53, Page 207

Titanium . . . booklet, 36 pp, is designed as reference for engineers, metallurgists and designers who desire the latest technical information. Harvey Aluminum Co.
For Your Copy, Circle No. 54, Page 207

Molybdenum . . . effect on elevated temperature strength of cast irons up to 1200 F is subject of research report. Climax Molybdenum Co.
For Your Copy, Circle No. 55, Page 207

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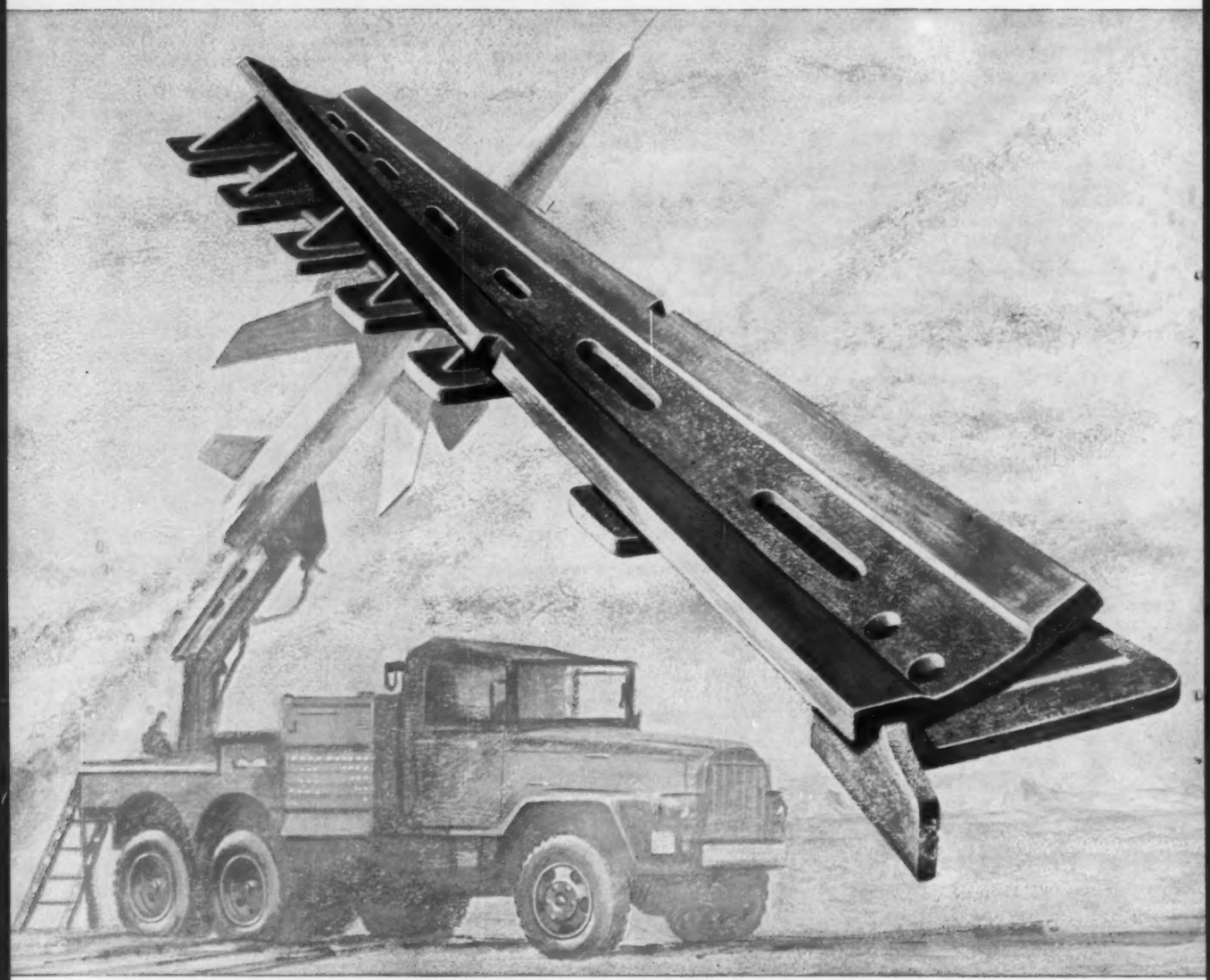
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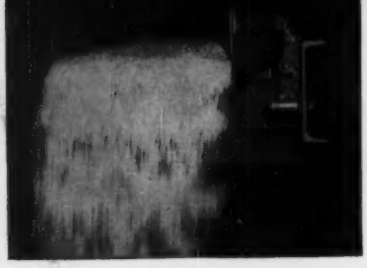
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Circle No. 195, Page 207

Seven Basic Steps Assure Clean Melt

by HARRY C. AHL
Malleable Iron Fittings Co.
Branford, Conn.

The purpose of melting is to provide metal in a suitable state for introduction into the mold with a minimum of difficulty and without impairing the quality of the metal. Melting can be done in many different types of furnaces which are capable of producing high quality melts at reasonable costs.

The major difficulties involved in melting consist of:

1) Dissolving gases.
2) Creating oxides.
3) Controlling metal temperatures.

Several recommended general practices used in successful foundries today are:

1) Use and charge only clean material of known composition.
2) Use only clean furnaces or clean crucibles for melting.
3) Melt as quickly as possible.
4) Melt in a near neutral to slightly oxidizing furnace atmosphere.
5) Do not superheat metal more than absolutely necessary to insure adequate temperature for metal as it enters mold.
6) After removing from the furnace, skim the molten metal carefully without stirring or excessive agitation.
7) Keep accurate temperature measurements of all melts.

Good melting essentially is a means of saving money by lower melt losses and higher good casting yield. Melt quickly; melt enough metal when needed but not too much; and provide metal when and where it is needed. Good melting invariably produces good quality and good quality is one step toward good castings. The recognition of good melting practice has been a problem in many shops.

It is necessary in all cases to establish good melting by means of determining the quality of the melt produced. This can be done by several means. One is a fracture test developed by the American Foundrymen's Society. Another is a fracture test developed by many individual foundries and somewhat simpler than that developed by AFS. Another is by chemical and mechanical properties as taken from test bars of the heat. Good melting is simply providing sound metal free of gases and free of nonmetallic inclusions.

It is not difficult to recognize good melting. One of the easiest measures is your cost of melting. High cost invariably results in bad melting; low cost generally reflects good melting.

Fluxing is definitely not a cure for bad melting but is instead a supplement to good melting practice. Fluxing consists of either chemical or mechanical treatment of the molten metal. Examples of mechanical treatment are: purging of melt by an inert gas; letting the metal stand in the molten state; or by use of covers in certain alloys.

Chemical fluxing is accomplished by adding various oxidizers or reducers such as phos copper, in the case of copper alloys, or by the so-called oxidizing reduction processes. Some molten metals require the use of reactive gases such as chlorine in aluminum or the hydrocarbon gases

The casting of certain metals requires fluxing. For instance, in casting pure copper you must flux with either a phos copper, calcium boride or lithium. And in the production of good, gas-free aluminum alloys, chlorine gas or one of the hydrocarbon gases may be a necessity. However, good melting produces high quality metal without the addition of fluxing.

As to the use of "covers," again, in some alloys they are necessary. For nickel silvers, monels, copper nickels, etc., glass is a much used cover. In most copper-based alloys, however, the use of a cover is not necessary. The use of charcoal can be dangerous in any metal inasmuch as it may be damp or may prevent the escape of mechanically entrapped gases. It must be born in mind that charcoal, even though appearing dry on the surface, may contain water of crystallization which I like to refer to as "dry water." When this is added to the molten metal, it breaks down into H_2O the same as though you had added wet water to the melt. In some of the aluminum alloys, top covers may be necessary to prevent excessive oxidation.

Melting of non-ferrous alloys is not difficult if we remember the seven basic steps previously mentioned. Good melting practice requires an understanding of the mechanics of melting plus good supervision and can definitely lead to lowered costs.

This article contains highlights abstracted from a paper presented at the 1959 Missouri Valley Regional Foundry Conference.



1

A comprehensive brochure on ductile iron, its properties and applications. Includes data on melting, desulfurizing, alloying, heat treating, and foundry practice. 23 pages including many illustrations and charts.



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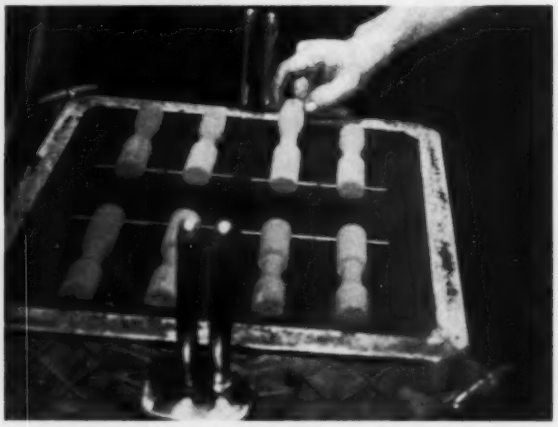
HERE'S HOW

. . . metalcastings are doing a better job, foundries are solving production problems, new products are resolving in-plant headaches. If you have an appropriate contribution for this department, send it to the editor of Modern Castings.

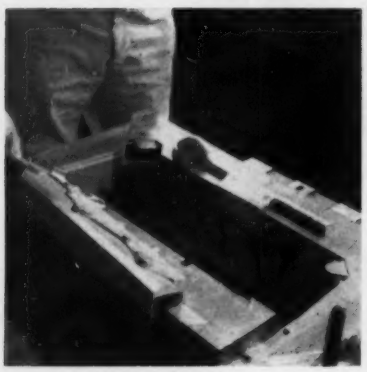
. . . **Green sand molds produce** precision gray iron castings ready for assembly without any machining. Lodge Mfg. Co., S. Pittsburgh, Tenn., makes these corn planter parts for Burch Plow Works, Evansville, Ind., in quantity with quality.

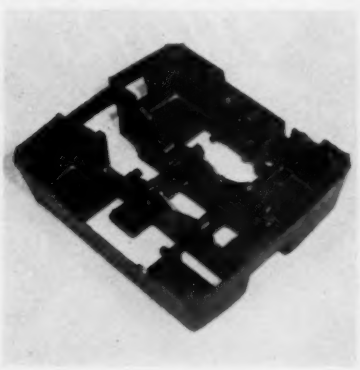


. . . **To support a core** when you can't have a core print. Metal wire passes through core and rests on parting face of drag mold—thereby supporting core "on center" in mold cavity. Lake City Malleable Co., Cleveland, uses this expedient in making malleable iron anchors which are cast into concrete foundations.



. . . **Intricate quality gray iron castings** like this can be made in green sand at Hamilton Foundry, Inc., Hamilton, Ohio. This bed for a piece of office equipment has enough bosses, flanges and undercuts to tax the most ingenious of foundrymen. Picture of pattern equipment shows how it's done with multitude of loose pieces and draw-backs. They do use a slab core in center of drag and several ram-up cores.







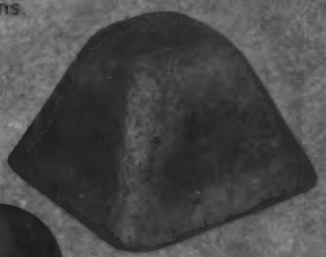
Circle No. 197, Page 207



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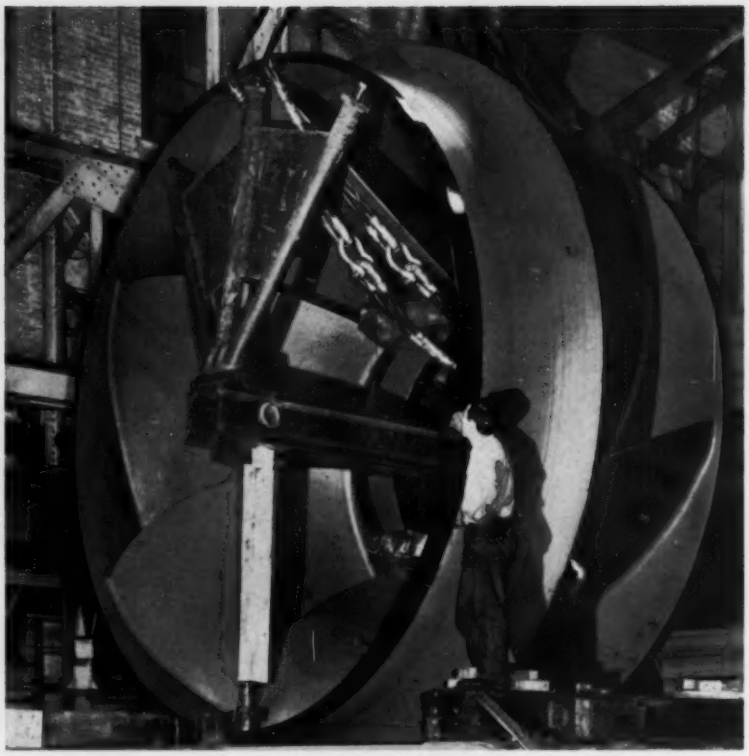
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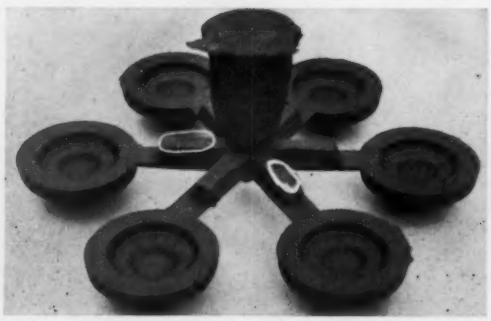
Continued from page 214



. . . **Cast-weld fabrication technique pays off.** This mammoth 50-ton runner for a reversible pump-turbine is an assembly of cast carbon steel buckets welded to a cast crown and runner band. Stainless steel segments are welded to lower portions of buckets for protection against pitting. Allis-Chalmers Mfg. Co., Milwaukee, built four of these units for Tuscarrora Pump & Power Plant, Niagara Falls, N. Y.



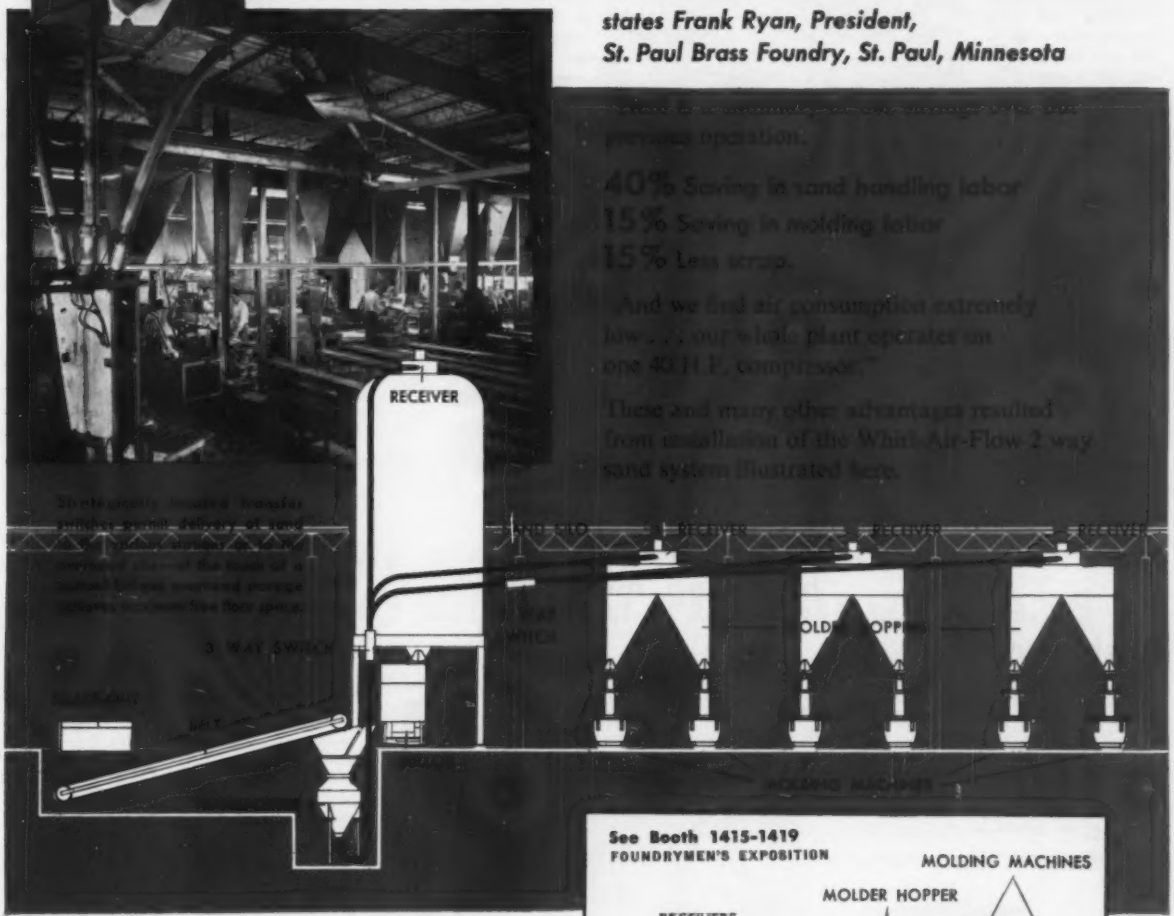
. . . **Knowledge** gained in AFS-T&RI Course—Gating & Risering of Castings—helped solve gating problems for Sirio D. Marchesi, Fabrica Argentina de Maquinas Agricolas S.A., Buenos Aires, Argentina. Circled areas in these three photographs show how dirt and slag were trapped in runner system before entering castings. The three different gating systems produced the highest quality gray and malleable iron castings compatible with reasonable economic consideration. Runner design technique was introduced into this South American foundry after Marchesi returned from a visit to the United States where he attended the course.





YES...small foundries can afford mechanization

states Frank Ryan, President,
St. Paul Brass Foundry, St. Paul, Minnesota

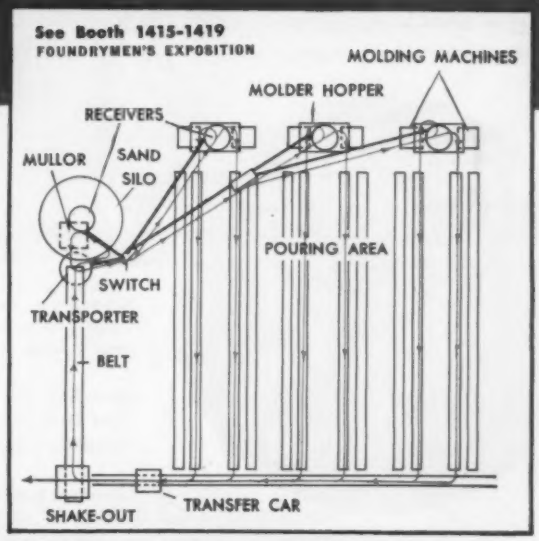


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Smelting and Alloying Technology of Copper Materials . . . Ernst Brunhuber. 252 pp. Geisserei-Verlag G.M.B.H., Dusseldorf, Germany. 1959. A comprehensive summary and discussion of the problems of smelting and alloying technology. Ways and possibilities are shown for the achievement of high-quality casting production. Designers of cast parts are alerted to conditions which make it possible to achieve a maximum high quality of production according to the present state of technology. Also included is a selection of proven processes for analysis and checking measures for the maintenance of quality.

Inventories and Business Health . . . Roy H. Foulke. Dun & Bradstreet, Inc., P. O. Box 803, Church Street Station, New York 8. 1960. A handbook for small businessmen explaining how uncontrolled inventories can cause business failures.

Sand and Chill Casting of Aluminum, 6th edition . . . Roland Irmann. 302 pp. Aluminum-Verlag Gmbh, Dusseldorf, Germany. 1959. This book covers a large variety of subjects including: basic raw materials, aluminum casting alloys, comparative costs of casting techniques, melting practices, temperature measurement, grain refining, degassing, gating and risering, permanent mold practices, coremaking, surface treatment, repairs, impregnating, welding, heat treatment, physical properties and testing, casting design and an extensive bibliography.

Vacuum Processes in Metalworking . . . J. Wesley Cable. 202 pp. Reinhold Publishing Corp., New York. 1960. Opening chapters deal with basic principles of vacuum technology. Later chapters describe metalworking processes conducted under vacuum such as melting, casting, deposition, sintering, brazing, welding and heat treatment. Information is presented in descriptive manner for ease of understanding.

Engineering Manual . . . John H. Perry and Robert H. Perry. 680 pp. McGraw-Hill Book Co., 330 W. 42d St., New York 36. 1959. A compendium of mathematics, mathematical tables, physical data and chemical data most commonly used in the architectural, chemical, physical, civil, electrical, mechanical and nuclear engineering fields. Handy reference designed to assist you in answering daily engineering problems.

Industrial Ventilation—A Manual of Recommended Practice, 6th Edition . . . Committee on Industrial Ventilation, Box 453, Lansing, Mich. 1960. A practical source of design data and information written by practicing ventilation engineers for use by designers, sheet metal fabricators and ventilation engineers. Chapters cover principles of ventilation, dilution ventilation, comfort ventilation, hood design, duct design, construction specifications, testing of systems, fans and air cleaning devices.

A Glossary of French-English, English-French Foundry and Metallurgical Terms . . . 28 pp. British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, England. 1959. This glossary aims to supply foundrymen and metallurgists with English equivalents of French terms commonly used in the literature of iron-founding and ferrous metallurgy.

Cemented Carbides . . . Paul Schwarzkopf and Richard Kieffer. 349 pp. The MacMillan Co., New York. 1960. The first six chapters furnish background information and describe the methods of producing carbides and other metallic refractories. The next six chapters summarize the mechanical and chemical properties of all the cemented carbides produced both commercially and experimentally. The final three chapters concentrate on applications of cemented carbides to machine-tool, mining, defense and other industries.

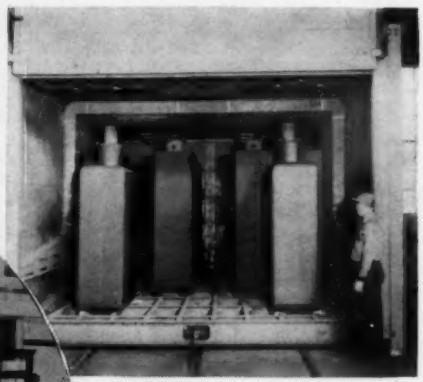
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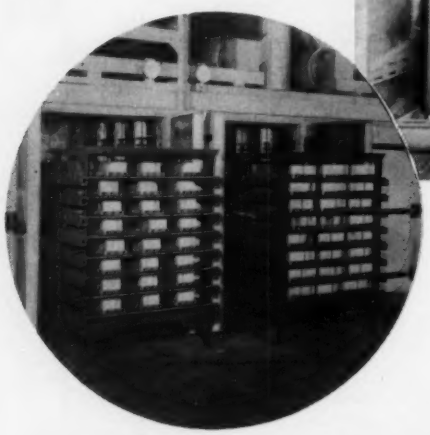
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(above) Car type mold drying oven installed at Centre Foundry, Wheeling, West Virginia.

(left) Rack type Recirculating Gas-Oil Fired Core Ovens at Golden Foundry, Columbus, Indiana.

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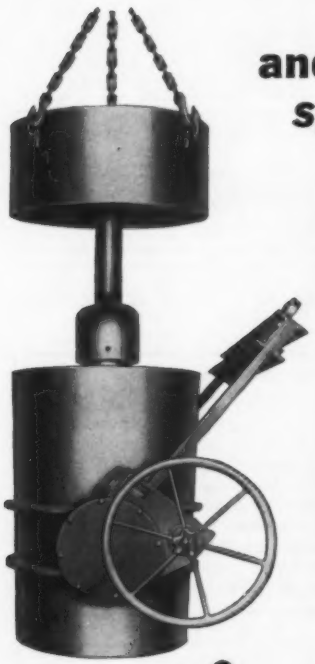
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Circle No. 199, Page 207

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Circle No. 202, Page 207

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HELP WANTED

FOUNDRY METALLURGICAL ENGINEER Wanted—foundry metallurgical engineer for non-ferrous foundry. Must have experience on problems of gating, risering, pouring, sands and cores. B.S. Degree in Engineering required. Must have minimum of five years experience. Age 28—50. Excellent opportunity for capable and energetic man. Salary open. Please reply stating your personal data, qualifications, experience, salary expected and availability in first letter. All inquiries will be held in strict confidence. Direct all correspondence to: **Ampco Metal, Inc., Personnel Department, Box 2004, Milwaukee 1, Wis.**

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FOUNDRY QUALITY CONTROL SUPERVISOR Immediate opening in Rochester, New York, firm for man to direct the inspection of castings and to maintain quality in modern steel, gray iron, and non-ferrous foundry. Firm recently completed million dollar expansion and modernization program in foundry. Applicant should have technical background and good experience. Should be familiar with gating and risering of steel castings. Excellent opportunity with substantial fringe benefits including profit sharing. Send resume of work experience and salary requirements to: **Box E-307, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.**

STEEL FOUNDRY METALLURGIST Experienced steel foundry metallurgist for carbon, low alloy and stainless foundry with emphasis on high alloys. Must be capable of directing chemical and physical testing laboratory, melting, sand control and planning operations. Location—Eastern Pennsylvania. Send complete resume, including salary requirement, which will be held in confidence. **Box E-305, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.**

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REPRESENTATION WANTED. Opportunity offered agents now having foundry lines represent leading distributor equipment and supplies for investment casting foundries. Open territories include Boston, Cleveland, Detroit, Chicago areas. Send resume to **Box E-301, MODERN CASTINGS, Golf & Wolf Roads, Des Plaines, Ill.**

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FOUNDRYMAN—age 49, 19 years experience, 9 years in sales and service. Supervisory and installation experience on latest automatic molding units and all phases of foundry operation. Know cupola, air furnace, sand control and rigging. Will consider traveling or superintendent position in gray iron or malleable foundry. Presently employed as Superintendent. **Box E-308 MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

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Serial No. 228-5312, New 1953.
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The above are in excellent condition, used only for experimental work.
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BACK VOLUMES — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals. **A. S. ASHLEY, 27 E. 21, N. Y. 10, N. Y.**

Dielectric Ovens Provide Fast, Even Drying to Cores

by M. B. MILONSKI
American Steel Foundries
Granite City, Ill.

Cores are baked in a dielectric oven as they pass between electrodes charged with high-voltage, high-frequency electricity. The molecular structure of resin binder in core is acted upon by the rapidly reversing electrical field so as to generate heat. This heat evaporates the moisture and polymerizes the low temperature synthetic resin binder. Complete drying takes two or three minutes for small cores and considerably longer for larger cores. As moisture evaporates, the core becomes a nonconductor. So its temperature drops, making it impossible to overbake.

American Steel Foundries purchased a 200 kw dielectric core oven with a split electrode. The electrode width, for one-half of the belt width, could be raised or lowered independently from the other side to permit drying cores of varied heights. This was the first time that a split electrode was incorporated into one of these dielectric units. The oven is actually two separate 100-kw units hooked up in tandem. They can be operated independently from one another, or together, each one having its own separate set of split electrodes and controls. The original specifications call for drying capacity of 10,000 lb of cores per hour with 3 per cent moisture.

To fully utilize the drying capacities of the oven, a coremaking layout was designed to encircle the feed-in-conveyor with incentive coremaking stations. Thus an ample supply of cores would be available to keep the feed-in-belt completely filled.

Following are the advantages and disadvantages of using the 200-kw dielectric core oven as we see them after approximately two years of production:

ADVANTAGES:

1) Core rodding can be reduced considerably because of the increased baked tensile strengths and reduced handling of cores in the green state.
2) Cores are dried very evenly, with good sharp corners, and will not overbake.
3) Dielectric ovens eliminate the necessity for drying racks, thereby reducing indirect labor and handling costs.
4) Reduced core inventories can be maintained because drying times are reduced from the normal 3-4 hours to approximately 15 minutes.
5) Incentive standards for coremaking have been appreciatively reduced because of the straight line flow from coremaker to conveyor belt, thereby eliminating former handling of cores to drying racks.
6) A definite improvement in working conditions results since heat is generated within the core. Small amount of smoke and fumes created can be handled by the exhaust system on the oven.
7) Drier and core plate inventories can be materially reduced because of their quick return from oven.
8) No costly superstructures or expensive foundations are necessary for dielectric type ovens.

DISADVANTAGES

1) New core plates must be made of a nonconductor-type material.
2) The use of miscellaneous core mixes is limited because phenolic resin is most suited for the dielectric oven.
3) Flexibility within the core department is reduced. Breakdowns cause costly delays and loss of production because we surround the inbound oven conveyor with many high production incentive coremaking units.
4) Fuel cost, as compared with gas-fired recirculating-type batch ovens, is approximately three times more per net ton of cores dried.
5) Maintenance costs and parts inventories will be much higher than with conventional core-drying facilities.
6) Metallic-type driers are unsatisfactory. Nonconductor-type driers of plastic or some other material must be used.

This article contains highlights abstracted from a paper presented at the 1959 Missouri Valley Regional Foundry Conference.

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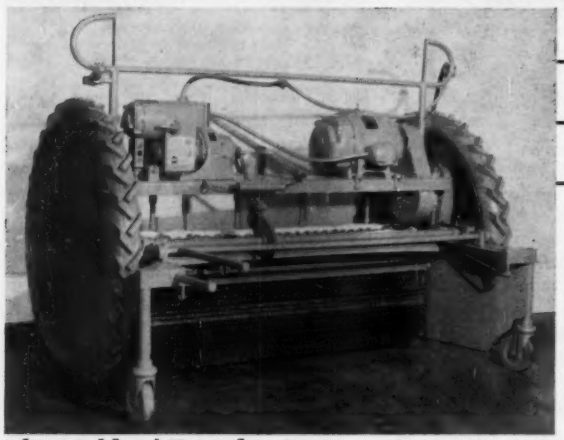
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"The Moulders' Friend"

MOBILE SAND CONDITIONER



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50" 60" 70"

OVERALL WIDTH
70" 80" 90"

THROAT WIDTH
53" 63" 73"

THROAT DEPTH
23" 23" 23"

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"The Moulders' Friend"
Dallas City, Illinois
Circle No. 201, Page 207





View of Gray Iron Pallet System. Pallets can be easily moved over rails by hand. Left: Plant Engineer Robert H. Clarke. Right: Scale mounted on fork truck weighs each component of charge.

ENGINEERING APPLICATIONS PAY OFF AT DALTON FOUNDRIES

INCREASED EFFICIENCY

To obtain faster, more efficient, production in the company's gray iron foundry, Robert H. Clarke, Plant Engineer at Dalton Foundries, Inc., Warsaw, Indiana, designed a pallet system. This flexible system allows molders to work two hours before pouring needs to begin. Cooling time can be varied to suit the job and pallets can be easily moved over rails by hand. No bottom boards are used and the handling formerly required to bring them back to the molders has been eliminated. The pallet system provides flexibility for both production and jobbing type work.

BETTER CONTROL

When bond and water are added to sand during mulling, the bond must be thoroughly combinded with water to be effective. Plant Engineer Clarke designed a system to pre-mix water and bond, and pump the mixture into a storage tank where it is stirred continually. From the storage tank, small amounts of the mixture are metered into a tank by a timer. Compressed air then blows this metered amount into the muller at the correct time. This system has resulted in better control of sand, faster mulling cycles, and easier handling of materials.

LOWER COST

At the Dalton Foundries the old wheelbarrow method used to charge the cupola required seven men. Clarke designed a scale which could be mounted on the front of a fork truck to weigh each component of the charge as it was loaded into a drop-bottom tub on the truck. After it is loaded, the fork truck delivers the material to the charging bucket. This simple, and inexpensive engineering change reduced the labor requirement to three men instead of the seven previously required.

You can help create a source of engineering talent for the foundry industry by participating in the FEF program as a contributing member.

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The Editor's Report

by Jack Schrum



Are these terms just foundry gobble-de-gook to you . . . fluidized bed . . . fluid diffuse plate . . . clay-saturated molding sands . . . effective clay . . continuous mulling . . . electronic moisture controller . . . electrical capacitance of sand . . . automatic monitoring . . . cathetometer measurements . . . purified exothermic gas . . . regression curves . . . confidence limits . . . phenolic novalaks . . . hexamethylenetetramine . . . magnetic permeability . . . gammographs . . . Webbert bar . . . x-ray fluorescent spectrograph . . . liquid-mushy interface . . . isochronous temperature distribution curves . . . plastic faced plaster technique . . . grain growth inhibition . . . peritectic reaction . . . constitutional supercooling . . . proeutectic phase? These are only a few of the terms that are creeping into the new foundry technology. They are all used in articles appearing in this copy of MODERN CASTINGS. You can become familiar with this important modern terminology of the times by reading your May issue. Otherwise, common foundry lingo will soon be jargon and you'll be on the wrong side of the communication barrier.

Vacuum venting . . . is a real positive way of removing gas from cores during pouring. Locate a perforated tube in center of core. Bring one end out of flask and put a Tee fitting on it. Attach compressed air hose and create Venturi effect which sucks gases out of core. This system also creates a negative pressure in the mold, thereby assisting molten metal to flow into thin sections which may be difficult to fill.

■ **Caustic solution saves caustic words . . .** in the cleaning room. Foundries using CO_2 cores and finding it difficult to shake out cores will be interested to know that the problem has been licked by using a 6 per cent caustic solution to collapse the cores. Chemical attack soon dissolves the binder and eases core removal. Cost—75 cents per ton of dissolved core. Incidently, CO_2 sands are being reclaimed with this same caustic solution.

■ **Cupola to air furnace to ladle-desulphurizer to arc furnace to reaction ladle . . .** sounds like a roundabout way to make ductile iron, doesn't it? But if you're running a malleable iron foundry like Stockham Valves & Fittings, Inc., Birmingham, Ala., you too might see the logic in this pentagon path. Stockham wanted to explore the ductile iron valve market and decided that air furnace malleable was a good base iron to start with. They flush a 1000-lb batch of this metal for a minute and a half in a ladle with CaC_2 in a N_2 carrier. This reaction drops sulphur from 0.12 per cent down to 0.01 per cent. Then the metal is poured into indirect arc furnace for addition of 1 per cent carbon and superheating. Fifteen minutes later it's tapped on magnesium-ferro-silicon and ductile iron comes out of the cauldron. The 10,000 lb of high strength valve bodies made this way every day are proving competitive with steel.

Some foundries figure . . . that for evrey hour saved in casting-cleaning time they save $20 on the cost of the casting. No wonder they post signs in the shop that read, **"Let's make our castings in the foundry, not in the cleaning room."**

Fugitive disposable pattern technique . . . sounds like a play on semantics or a variation of the lost-wax theme. Armour Research Foundation has come up with this one. According to Paul Gouwens of Armour, the process was developed to meet requirements for accurate cast-to-size forging dies. Pattern negative for cope is faced with a layer of wax which is backed up with plaster. Drag half is similarly made. The wax-faced plaster pattern is then given a refractory wash which is backed up with a granulated graphite-bentonite mold material. Mold is fired, wax melts, wash adheres to mold back-up material and pattern is destroyed. Result is an extremely accurate mold capable of receiving molten temperature-resistant steel alloys such as HE-1049. Surface and dimensions are excellent. Die is ready for mounting without expensive contour machining.

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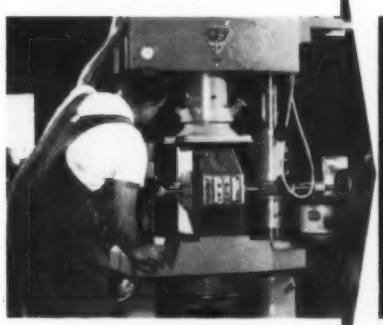
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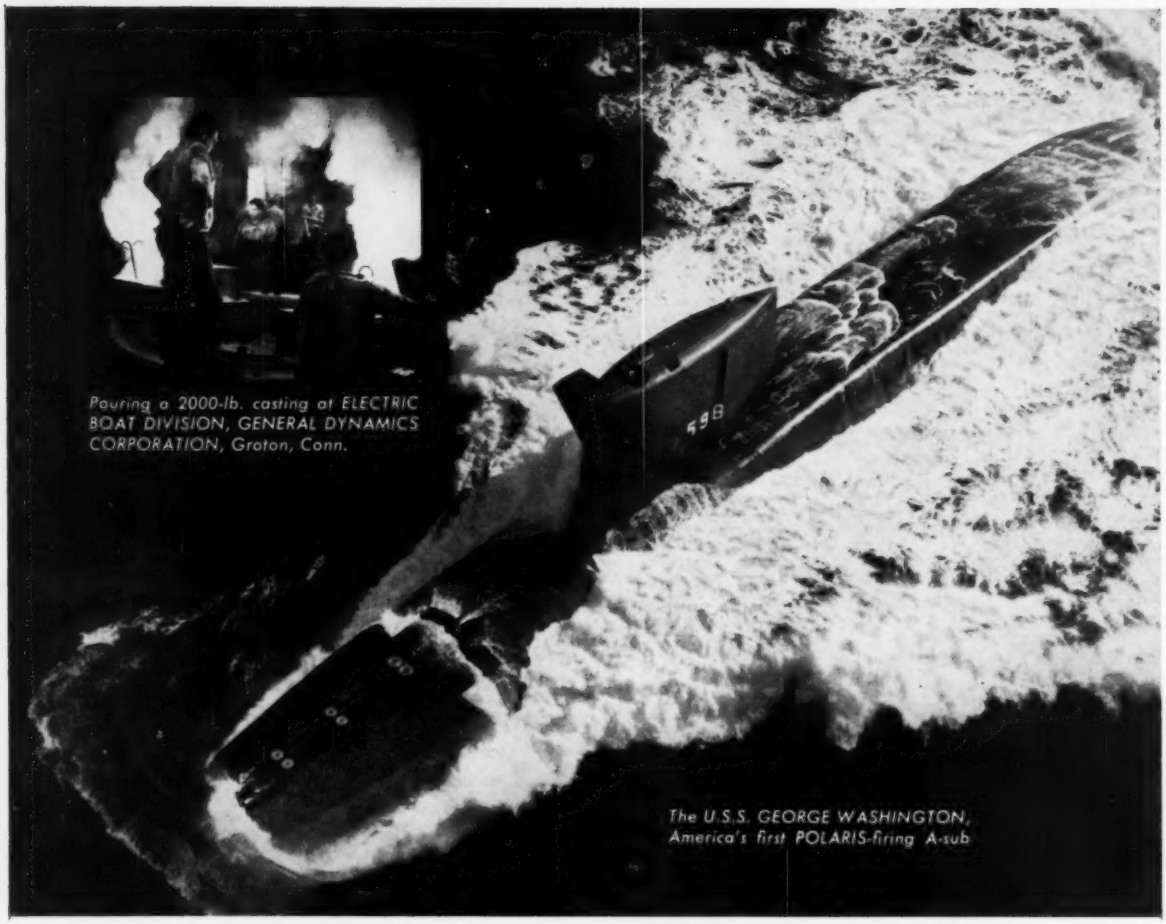


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RCI Core Binders

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• Precision castings are critical pieces in ELECTRIC BOAT's gigantic A-sub production puzzle. Every phase of the project is tightly security-sealed. While it is no secret that a variety of A-sub valves, structural boxes, gear cases and other components, are poured — in aluminum-bronze, manganese-bronze, super-nickel and other metals — specifics are unavailable. One thing's for sure: castings must be perfect! And, it is reported that in operations where ELECTRIC BOAT is using RCI Core Binders, they find that excellent results are obtained.

If you have a core binding problem, chances are RCI has already found the answer. Liquid phenolic, liquid amino and liquid oleoresinous core binding resins, liquid sand conditioners, liquid binders (self-curing), and liquid phenolic, powdered phenolic and granulated phenolic resins for shell coremaking and shell molding are all on the list of RCI Foundry Products. Let's talk about Reichhold resins in terms of *your* applications.

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